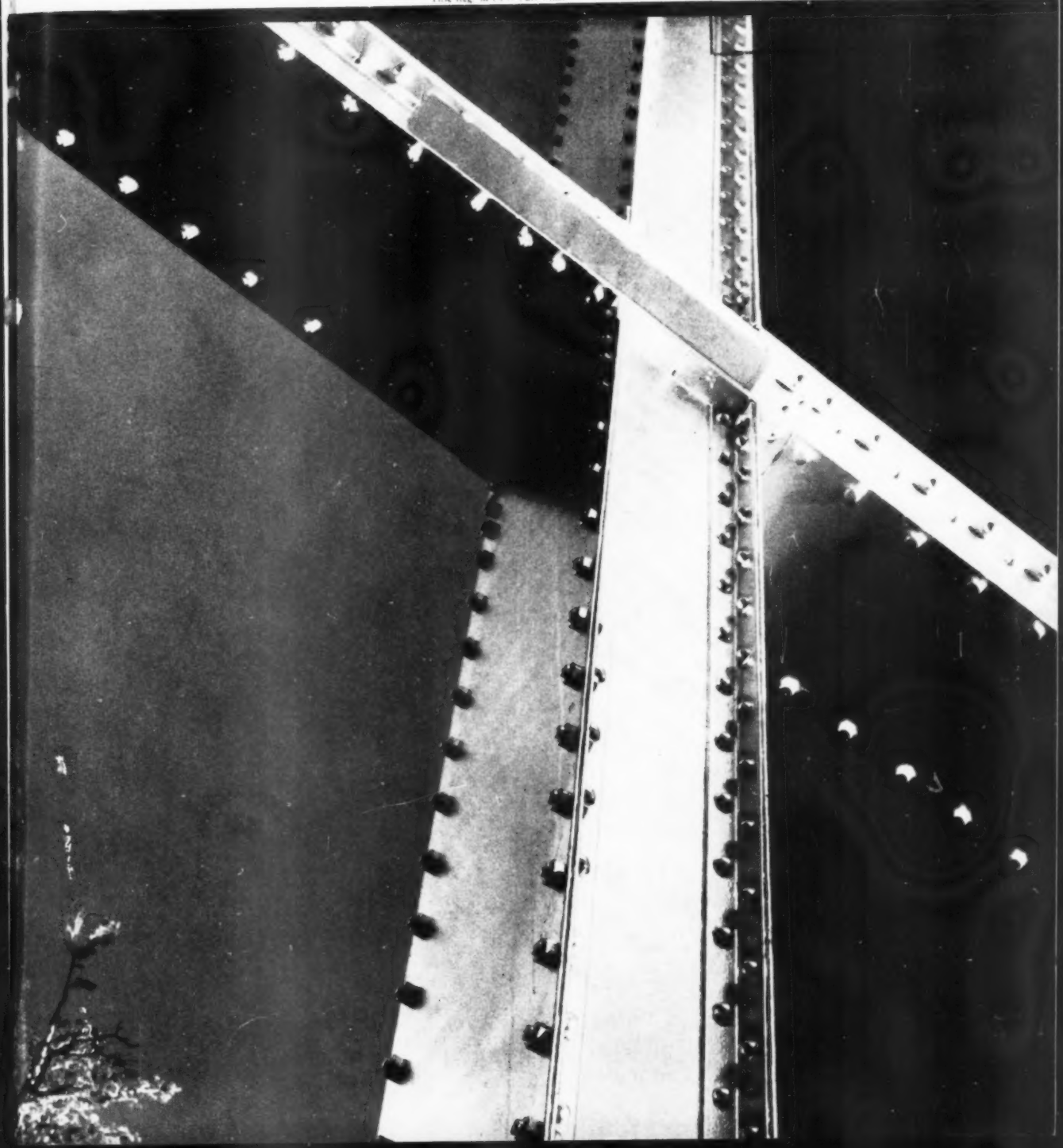
NOLOGY DEPARTMENT

November 1947

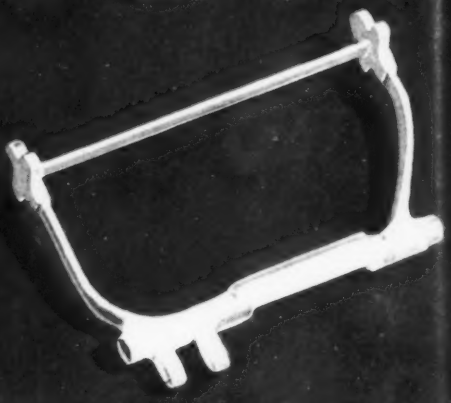
TECHNOLOGY REVIEW

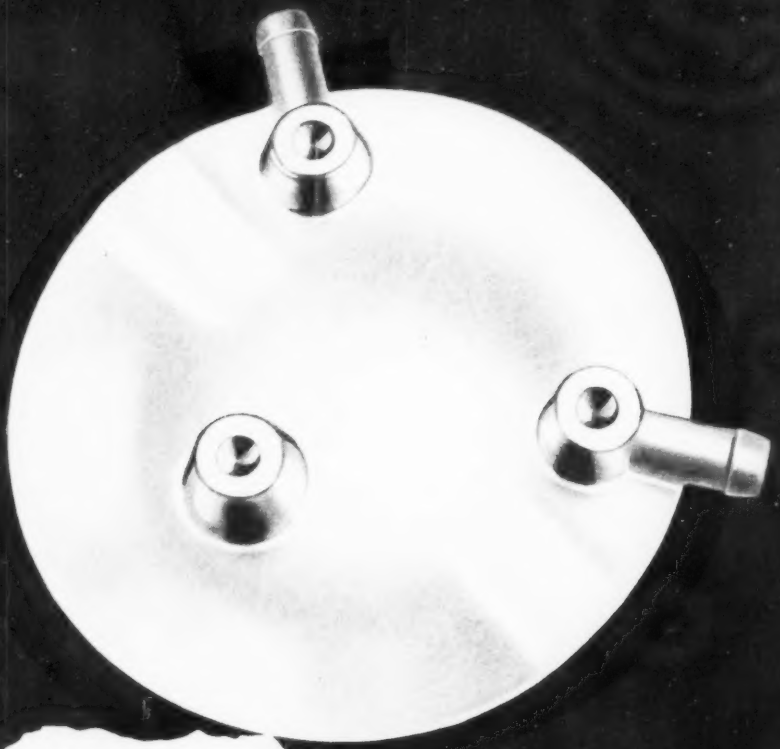
Title Reg. in U. S. Pat. Office

PUBLIC LIBRARY
NOV 12 1947



Brass... SMOOTH FORGED





SIMPLE OR INTRICATE

THE HARVEY

METAL CORPORATION

• Engineers & Manufacturers •

74th STREET and ASHLAND AVENUE • CHICAGO 36, ILLINOIS

FORGINGS IN ALUMINUM • BRASS • BRONZE • COPPER • MAGNESIUM • MONEL • ALLOYS

MACHINING FACILITIES

A MESSAGE ABOUT ECONOMY TO MANAGEMENT

Why Safety Goggles are a Worthwhile Investment for Management

PUBLIC LIBRARY
NOV 12 1947
DETROIT

Yield of Industrial Bonds
Approximately **3%**

Yield of Common Stocks
4-7%

"Yield" of SAFETY GOGGLES

that prevent 98% of Eye Accidents

233%

Industrial eye accidents average $5.00 per worker per year. Where else on an expenditure of $1.50 (average cost of goggles) could you obtain a "return" of $3.50—or *233%* on your investment? Your AO Safety Representative has complete details about how an adequate eye protection program can cut *your* costs.

American Optical COMPANY — *Safety Division*

SOUTHBRIDGE, MASSACHUSETTS • BRANCHES IN PRINCIPAL CITIES

THE TECHNOLOGY REVIEW, November, 1947. Newsstand Edition. Vol. L, No. 1. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

√R v.50 Nov. 1947 – July 1948

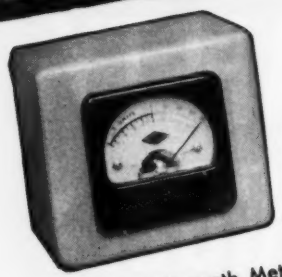
OUTSTANDING FEATURES

- Continuous frequency coverage from 550 kc. to 55 mc. Bandswitching in 5 ranges. Bandspread tuning at any frequency.
- Seven tube superheterodyne (plus rectifier and voltage regulator).
- Automatic Noise Limiter.
- Built-in loudspeaker and A.C. power supply.
- R. F. stage with panel controlled antenna trimmer.
- Operates from 105-130 volts, 50-60 cycles A.C. (Provision for battery operation.)
- Housed in a streamlined gray cabinet.

AMATEUR NET.....$89.50

HERE IT IS—THE NEW NC-57

National NC EST 1914



The SM-57 Signal Strength Meter has been designed as an accessory to be used in conjunction with the NC-57.

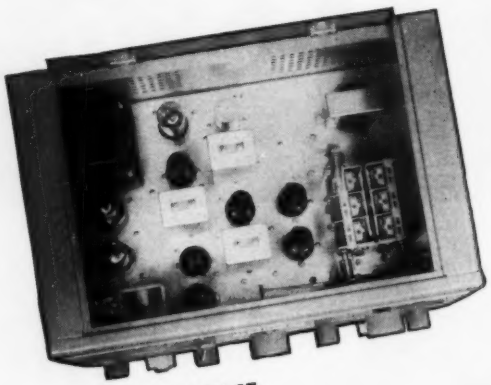
To meet the needs of the many hams who have asked for a sensitive, first-rate bandswitching receiver in the lower price bracket, complete with speaker and power supply in one cabinet, the National Company has developed the brand-new NC-57.

The CW operator will enjoy the stable operation and excellent signal-to-noise ratio of the NC-57.

The phone operator will be pleased with the tone quality and selectivity.

The SWL will log DX stations with ease and clarity. In fact, any operator now operating a communications receiver will find the NC-57 essential as a standby.

In this price class, the new National NC-57 is an outstanding value. See and hear one at your local distributor's ham shack this week.



INTERIOR OF NC-57

National Company, Inc.
Dept. No. 18
Malden, Mass.

Tech.

MAKERS OF LIFETIME RADIO EQUIPMENT

32 ALUNDUM

One Year Old

. . . And Every Bit as Good as Predicted

32 ALUNDUM abrasive has made good on every one of the Hollywood adjectives used to describe it a year ago. In plant after plant 32 ALUNDUM grinding wheels really are proving sensational — really do cut costs by:

grinding faster
grinding cooler
having longer life
requiring fewer dressings

32 ALUNDUM abrasive is entirely new — made differently by a Norton-invented and Norton-patented process.

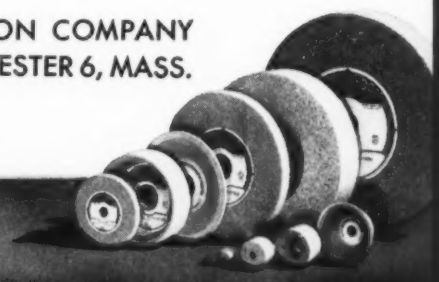
Each grain is a single, complete crystal — not crushed to size.

Each grain has many sharp points on all sides for faster, cooler cutting.

Each grain is over 99% pure fused alumina for greater resistance to dulling.

32 ALUNDUM wheels are available in *all standard sizes*. They can cut costs for you on cylindrical, centerless, surface, tool and internal grinding.

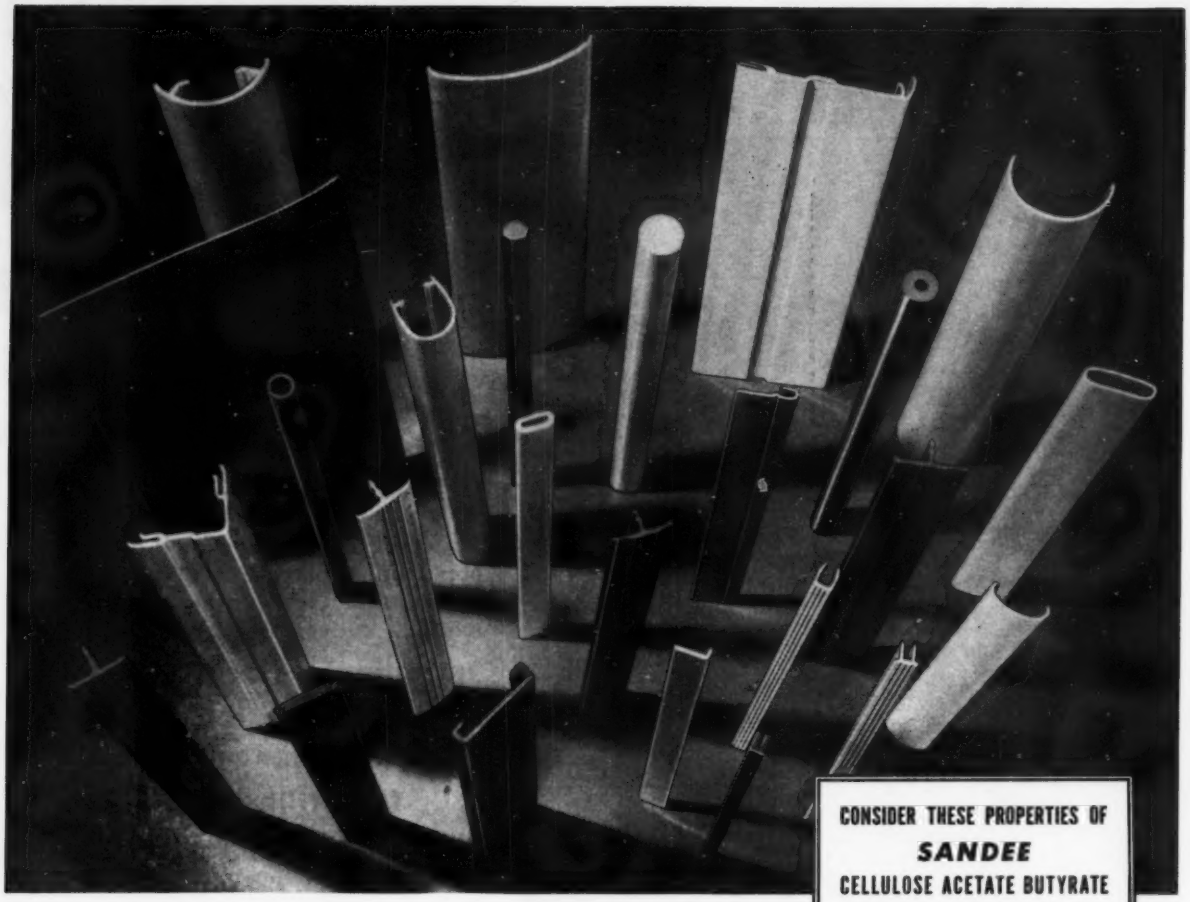
NORTON COMPANY
WORCESTER 6, MASS.



NORTON ABRASIVES

The Greatest Cost-cutting Development in Abrasives in Over Forty Years

*Trade-mark reg. U.S. Pat. Off.



CONSIDER THESE PROPERTIES OF
SANDEE
CELLULOSE ACETATE BUTYRATE

1. *Specific Gravity*	—1.22
2. *Tensile Strength*	—3000 to 5000 p.s.i.
3. *Impact Resistance*	—Excellent at normal temperatures
4. *Heat distortion*	—170° to 185°F.
5. *Rigidity*	—Good to very good
6. *Dimensional Stability*	—Good to very good
7. *Water Absorption*	—1 to 2%
8. *Burning Rate*	—Slow
9. *Odor*	—Nil to faint
10. *Color*	—Unlimited
11. *Finish*	—Excellent
12. *Machinability*	—Excellent

Sandee CELLULOSE ACETATE BUTYRATE *Extrusions*

THIS general purpose material, under the trade name TENITE II, has attained an excellent reputation for appearance and serviceability in widely diversified fields. This is not only true in injection molded and fabricated items but is equally true in Extruded Rods, Tubes, and simple and complicated shapes. Colorful, tough, easily machined and easily formed to fit specific contours, it is serving to complete satisfaction in fields ranging from rods and tubes for toys to furniture and refrigerator trim.

Study the properties of this excellent general purpose material, then check with *Sandee* for confirmation of suitability to your requirements. *Sandee's* practical know-how in extrusion often helps in altering designs for improvements in functional utility, appearance, and cost.

SALES REPRESENTATIVES IN 19 PRINCIPAL CITIES

Sandee Manufacturing Company

5050 FOSTER AVENUE • CHICAGO 30, ILLINOIS

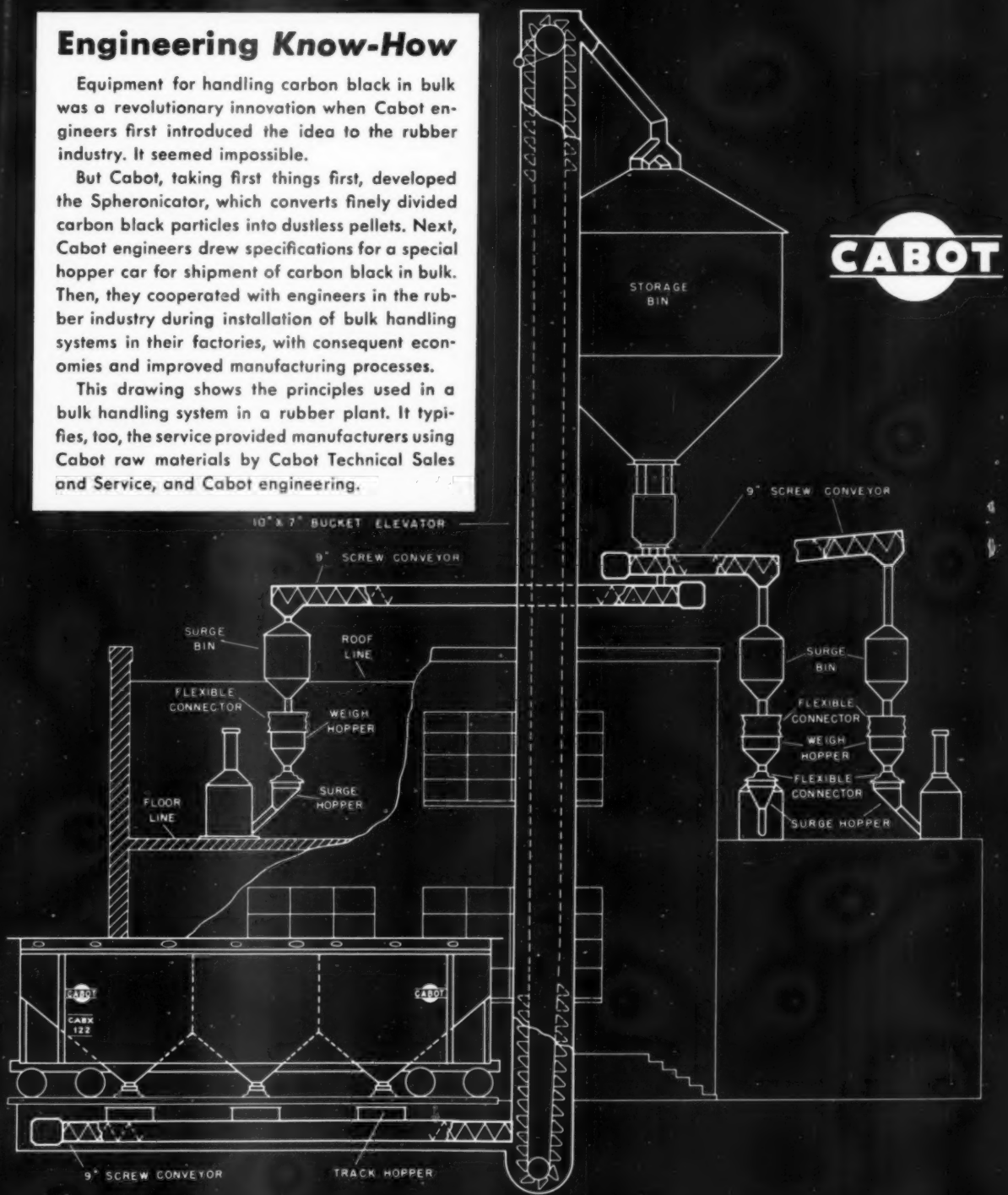
EXTRUDED PLASTICS AND SPECIAL TOOLS

Engineering *Know-How*

Equipment for handling carbon black in bulk was a revolutionary innovation when Cabot engineers first introduced the idea to the rubber industry. It seemed impossible.

But Cabot, taking first things first, developed the Spheronicator, which converts finely divided carbon black particles into dustless pellets. Next, Cabot engineers drew specifications for a special hopper car for shipment of carbon black in bulk. Then, they cooperated with engineers in the rubber industry during installation of bulk handling systems in their factories, with consequent economies and improved manufacturing processes.

This drawing shows the principles used in a bulk handling system in a rubber plant. It typifies, too, the service provided manufacturers using Cabot raw materials by Cabot Technical Sales and Service, and Cabot engineering.



GODFREY L. CABOT, INC.

77 Franklin Street, Boston 10, Mass.

AFTER YOU GET BACK FROM THE SHOW...

don't get off this one train of thought

Don't sidetrack all those ideas on new products, markets and cost-reduction which you brought back, red hot, from Chicago — just because you lack plant facilities, equipment, or hours in the day.

Take your new ideas — or your bothersome old problems—to Taft-Peirce, where you will find all these services and products at your ready command:

Engineering, Tooling, Contract Manufacturing: To your specs or blueprints, the T-P Contract Division will tool and produce anything from a single tool or part to complete mechanisms in lots of any quantity.

Special Gear Cutting & Grinding, Thread Milling & Grinding: A new department with ample capacity for cut or ground gears and threads of all types.

Standard Machine Tools: The No. 1 Precision Surface Grinder and the 6″ Rotary Surface Grinder for high precision and fine finish on small flat work. The New Taft-Peirce Spline and Gear Grinder. The Taft-Peirce Back Spot Facing Machine.

Production and Inspection Tools: Sine bars and fixtures, squares, surface plates, bench centers, angle-measuring equipment, etc.

Standard & Special Gages: All types of AGD Standard plain and thread plug, ring, and snap gages. Special designs to specification. The new Taft-Peirce CompAIRator air gage.

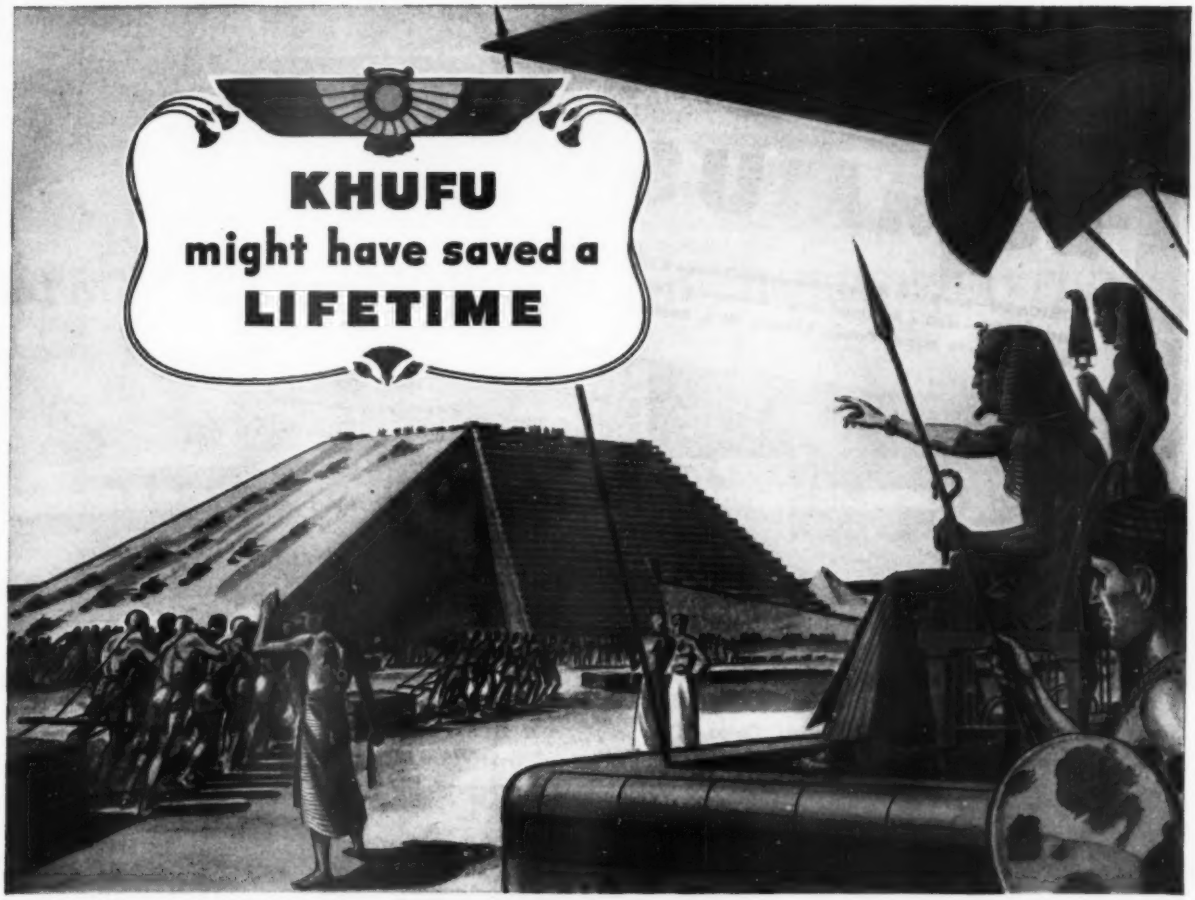
Magnetic Chucks: Rectangular, rotary, and tilting-base chucks of exclusive T-P SUPER-POWER design. Magnetic V-blocks and angle plates.

Write to The Taft-Peirce Mfg. Co., Woonsocket, R. I.

. . . for Engineering, Tooling, Contract Manufacturing

TAKE IT TO TAFT-PEIRCE

T-P



KING KHUFU had only *slave*-power with which to build the greatest of the pyramids. With engine-power, he might have saved a lifetime and the lives of 300,000 slaves.

Today, mightier and much more useful structures spring from dream to drawing board to reality in relatively short spans of time. Modern construction equipment powered by internal-combustion engines makes this possible. For today, the machine is the slave of man. Great dams, soaring bridges, towering buildings and broad highways are ours without backbreaking toil and wasted flesh and blood.

AMERICAN BOSCH CORPORATION, SPRINGFIELD 7, MASS.

PARTNERS IN THE PROGRESS OF POWER

American Bosch works closely with and for the internal-combustion-engine industry in three vital ways:

ENGINEERING. 1,200,000 *man-hours* of it have been poured into Diesel Fuel Injection alone—other millions into Ignition.

PRODUCTION. *Premium performance* has been a consistent goal in the production of hundreds of thousands of Diesel injection systems and millions of electrical units.

MAINTENANCE. *The world over,* American Bosch authorized service stations keep the equipment operating efficiently.

AMERICAN BOSCH

DIESEL FUEL INJECTION • AUTOMOTIVE AND AVIATION ELECTRICAL PRODUCTS

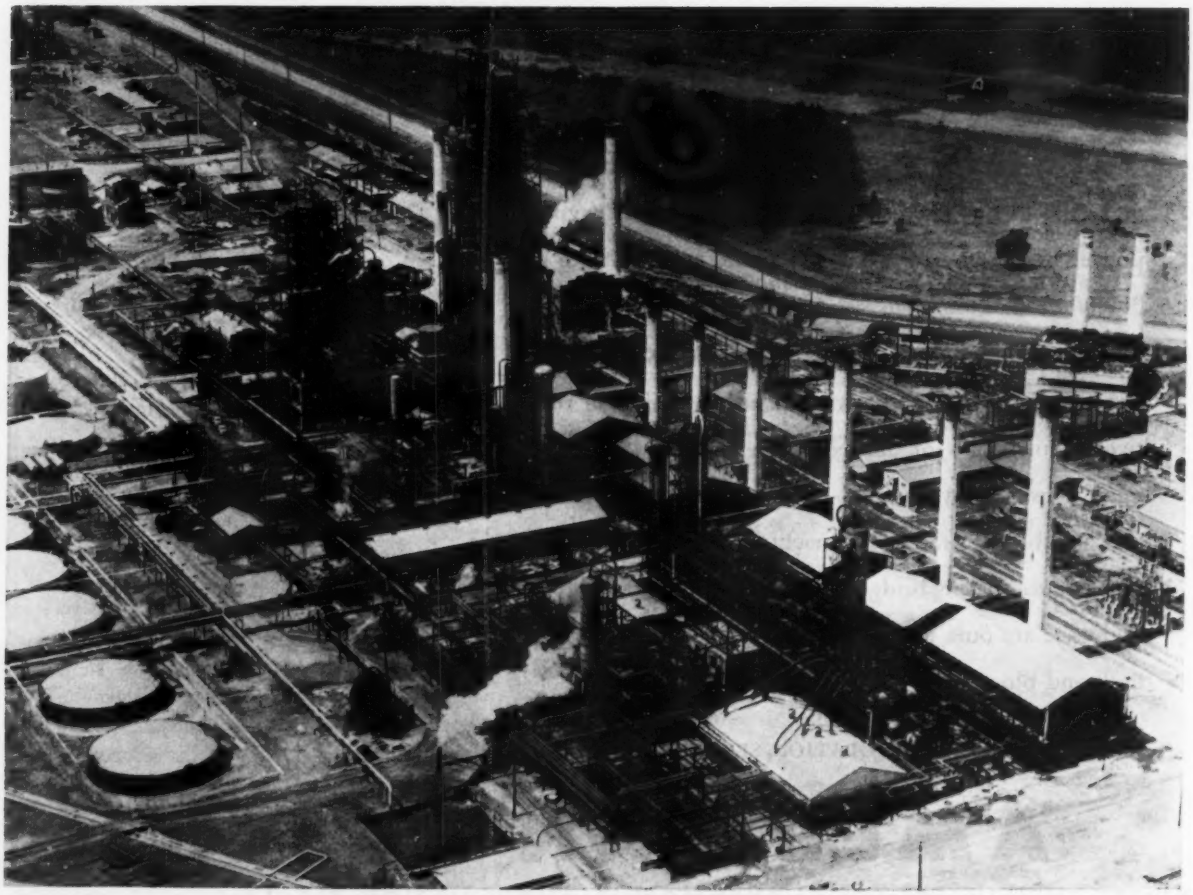
THE LUMMUS COMPANY
420 Lexington Avenue, New York 17, N.Y.

LUMMUS

CHICAGO—600 South Michigan Avenue, Chicago 5, Ill.
HOUSTON—Mellie Esperson Bldg., Houston 2, Texas
LONDON—78 Mount Street, London, W. 1, England

—an integrated service extending from engineering surveys of existing facilities and economic studies to the design, construction and initial operation of refinery process units and chemical manufacturing plants.

High Octane Gasoline Plants, Including Catalytic Cracking, Combination Thermal Cracking and Thermal Polymerization Units.



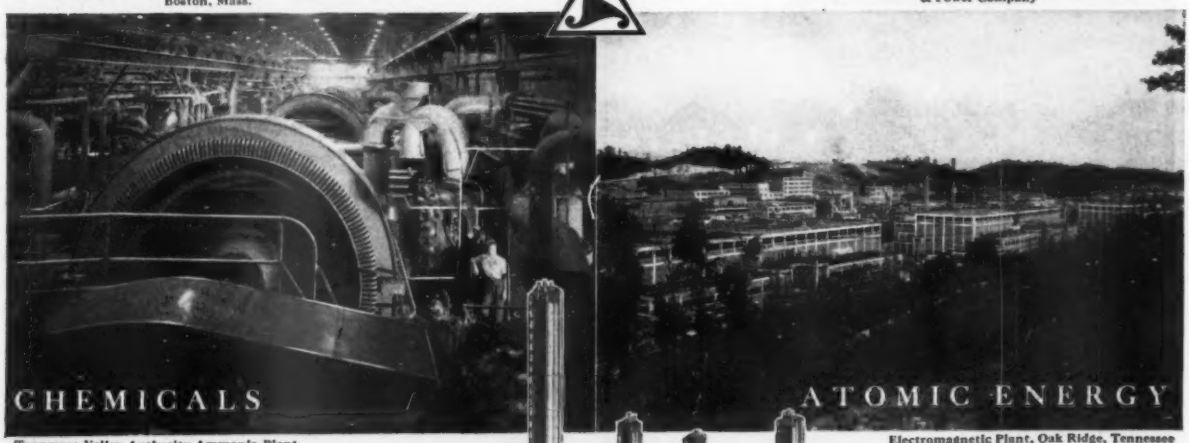
Chase Brass & Copper Company, Euclid, Ohio

SPECIALIZED KNOWLEDGE IN DIVERSIFIED FIELDS

Proposed Children's Medical Center, Boston, Mass.

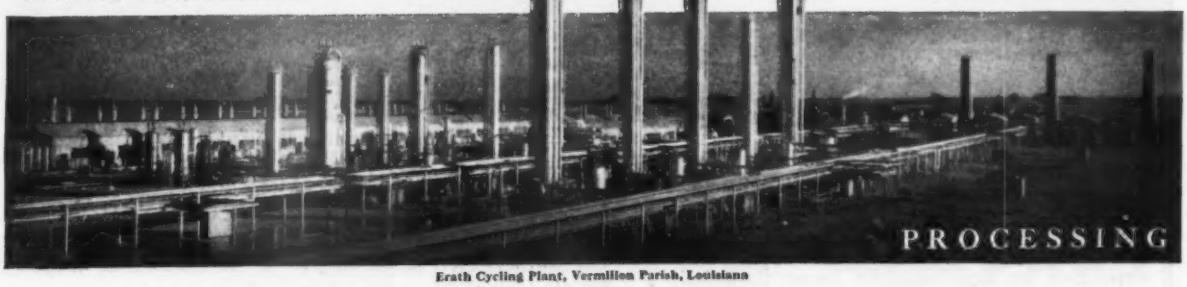
Since 1889, Stone & Webster Engineering Corporation has been engaged in the solution of design, engineering and construction problems. This experience is available to companies looking toward the future.

Chesterfield Power Plant, Virginia Electric & Power Company



Tennessee Valley Authority Ammonia Plant

Electromagnetic Plant, Oak Ridge, Tennessee

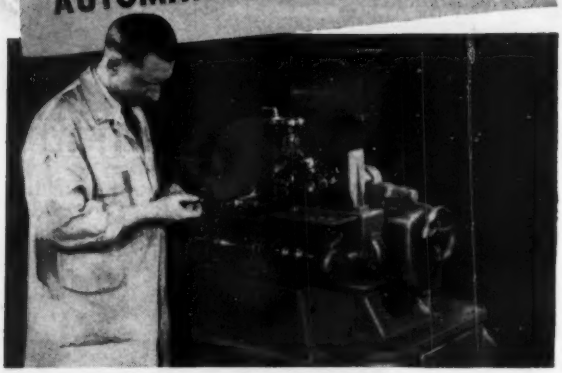


Erath Cycling Plant, Vermilion Parish, Louisiana

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER INC.

NEW DESIGN "OOG" AND "OG" AUTOMATIC SCREW MACHINES



● These Automatic Screw and Automatic Cutting-Off Machines feature 196 two-speed combinations including a wide range of high to low speed ratios. Equal cutting efficiency is obtained on all materials from alloy steel to plastics, and on the widest range of work diameters. Large assortment of attachments available. Complete details and specifications on request. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

BROWN & SHARPE B·S

Reg. U. S. Pat. Off.

Samson Cordage Works

Boston 10, Mass.

Manufacturers of braided cords of all kinds, including sash cord, clothes line, trolley cord, signal cord, shade cord, Venetian blind cord, awning line, etc., also polished cotton twines and specialties.

SPOT CORD

Reg. U. S. Pat. Off.

Our extra quality sash cord, distinguished at a glance by our trade-mark, the colored spots. Especially well known as the most durable material for hanging windows, for which use it has been specified by architects for more than half a century.

THE TABULAR VIEW

Aviation Progress. — In the future, speed and weight of aircraft are not factors which the aeronautical engineer alone may determine; rather are they matters which will require the wholehearted co-operation of construction engineers as well. The reason for this state of affairs, as LIEUTENANT COLONEL WILLARD ROPER, '38, enumerates (page 24) is that for several years already large aircraft have taxed terminal ground facilities which can be built economically with present construction methods. Thus, in the opinion of Colonel Roper, future progress in air power must await advances in construction power. As a student Colonel Roper was active in extracurricular affairs and received his degree from the Institute in 1938. Upon completion of his studies in Course XV, he was an industrial engineer for the Electrolux Corporation until he entered active military service in July, 1941, as an officer in the Corps of Engineers. From October, 1942, to December, 1945, Colonel Roper held various air engineering posts in the Army Air Forces. He accepted a regular Army commission in July, 1946, and is now Assistant Air Engineer, Headquarters, Army Air Forces, Washington.

Research for Education. — From time to time, and particularly in the past six years, it has been reported that the vast program of research in which the Institute has necessarily participated, has sometimes caused eyebrows to be raised. Fundamentally, of course, M.I.T. is an educational institution whose foremost product is capable men (and women) thoroughly trained as engineers and scientists. Certainly research will play a most important role in the professional lives of Technology graduates. It should not be too much to expect research to make its own unique contribution to their education. The Review is pleased to publish (page 29) an address on this subject, presented in Minneapolis last summer before the American Society for Engineering Education, by JAMES R. KILLIAN, JR., '26, Vice-president of M.I.T. With unusual competence, Dr. Killian takes advantage of his present administrative post and his past achievements as editor of The Review in conveying the message that the contribution which research may be expected to make in advancing higher education is the policy guiding the Institute's acceptance of sponsored research projects.

Fresh Air for Industry. — Although constituting one fifth of the air we breath, oxygen has been limited in its industrial applications because of its relative scarcity resulting from high price. The many industrial processes which can be made considerably more efficient and effective through greater utilization of oxygen are about to obtain a new lease on life as a result of recent methods for producing large quantities of oxygen of high purity at low cost. From a technical point of view, some of the methods for supplying industry with fresh air have already been enumerated in The Review last January by Samuel C. Collins. In this issue EARL P. STEVENSON, '19, President of Arthur D. Little, Inc. presents (page 32) an authoritative discussion of the future role of oxygen in industry. After receiving his bachelor of science degree from Wesleyan University in 1916, Mr. Stevenson spent

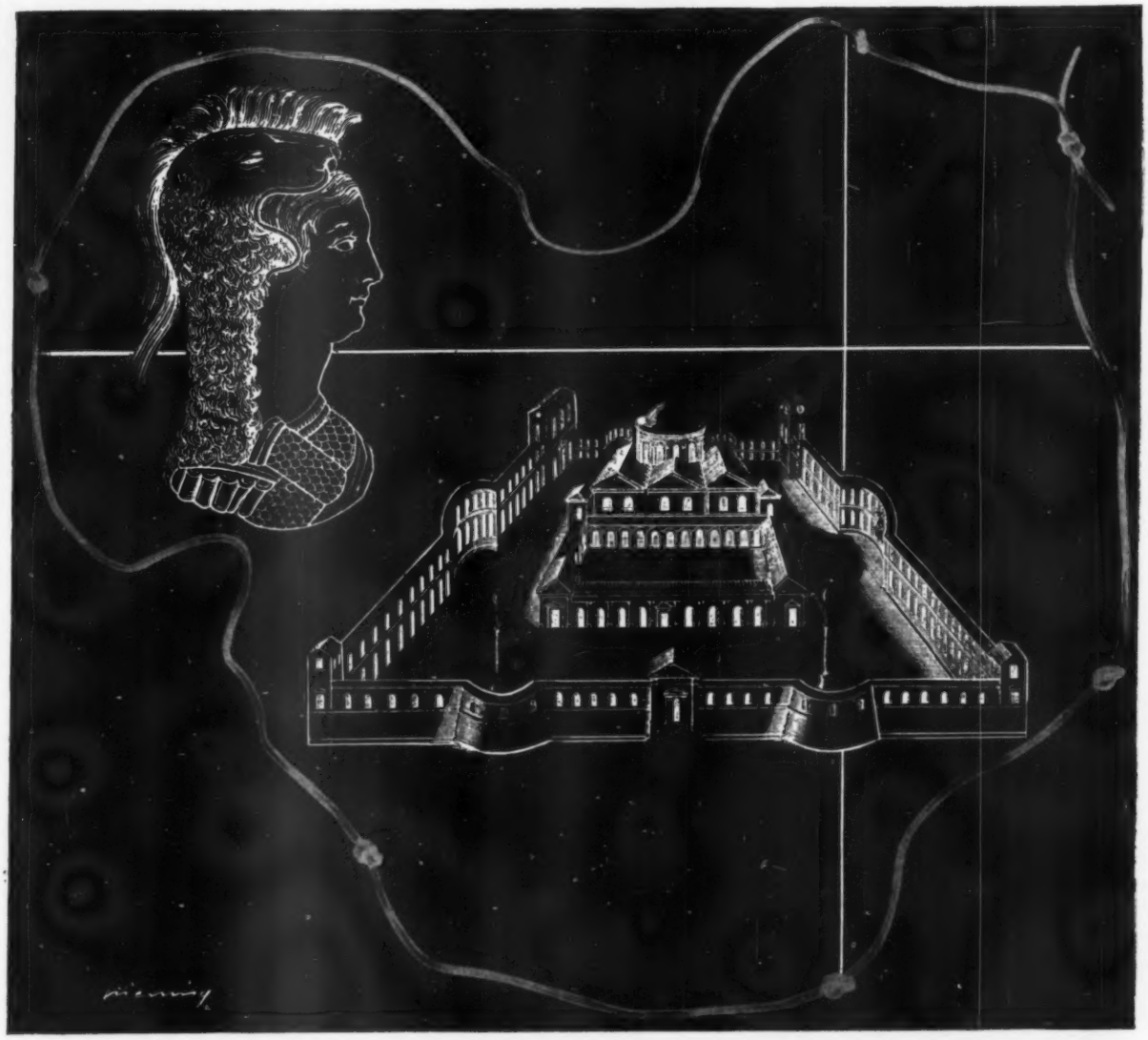
(*Concluded on page 14*)

A LITTLE DOES A LOT

According to legend, when the city of Carthage was founded, Queen Dido was told that she could have only as much land as could be encompassed by an ox hide. But the queen made the most of her material by cutting it into a single, continuous leathern string, with which she circled considerable acreage.

Making materials serve to the fullest is just as important to users of steel today as it was to Dido. Except that today no tricks are necessary.

It can be done in many instances by specifying molybdenum steels. Their hardenability, freedom from temper brittleness and good strength-weight ratio help to simplify design problems and insure good performance. It will pay you to investigate their practical advantages.



MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

Climax Molybdenum Company
500 Fifth Avenue • New York City

MOLY

ARNOLD

PERMANENT MAGNETS

Depend on them for Uniformly High Quality in every PHYSICAL, MAGNETIC and METALLURGICAL Characteristic

You would find it hard to set a requirement on Arnold magnets that is not already exceeded in our regular production procedure.

All Arnold products are made on a basis of 100% quality-control at *every* step of manufacture. These rigidly maintained standards cover all physical, magnetic and metallurgical characteristics. . . you can place complete confidence in the uniformity and dependability of Arnold Permanent Magnets, and their resultant performance in your assemblies.

Remember, too, that Arnold's service covers all types of permanent magnet materials, any size or shape of unit, and any field of application. Our engineers are at your command—write us direct or ask any Allegheny Ludlum representative.

W&D 1098

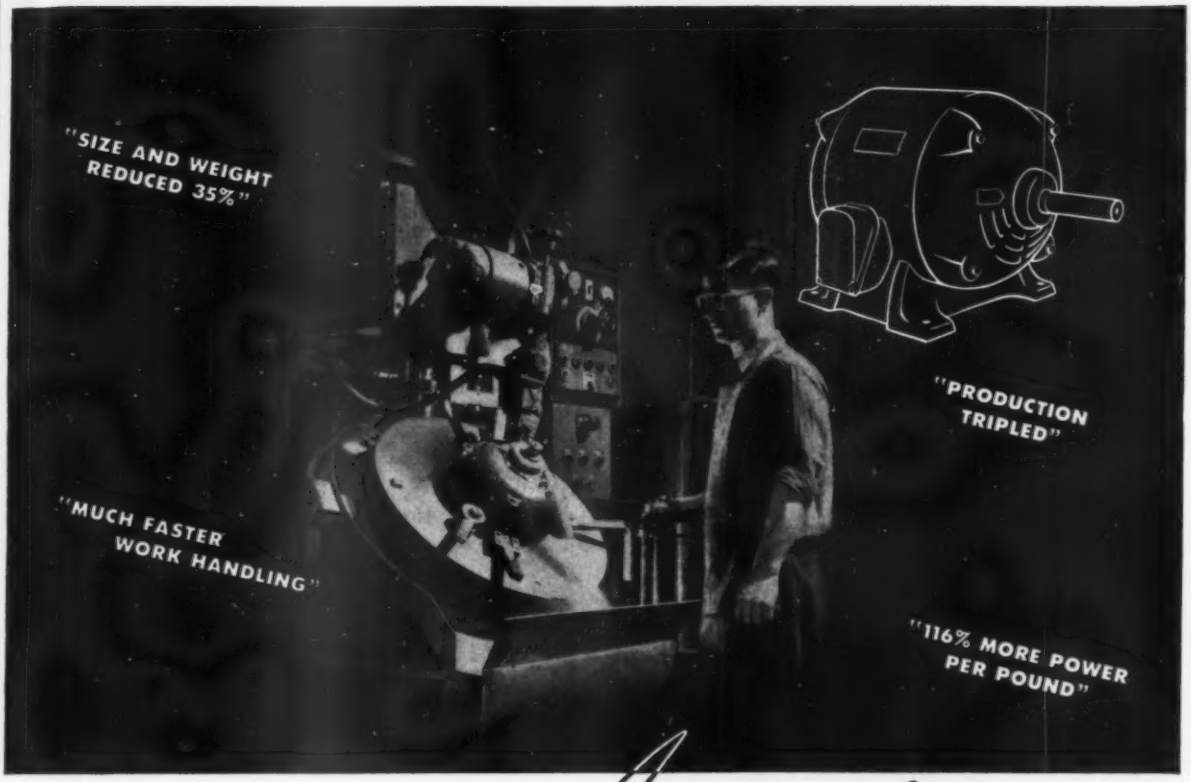
THE ARNOLD ENGINEERING COMPANY

Subsidiary of

ALLEGHENY LUDLUM STEEL CORPORATION

147 East Ontario Street, Chicago 11, Illinois

Specialists and Leaders in the Design, Engineering and Manufacture of PERMANENT MAGNETS



PRIZE TESTIMONIAL FOR *Automatic Welding*

from our own production experience

INVESTIGATE!

Automatic welding is just one of many new or improved electrical techniques for producing faster, cheaper, better. Westinghouse engineers can quickly give you salient facts on others applicable to your industry, including the following:

- Induction Heating (metals)
- Dielectric Heating (non-metals)
- Infrared Drying
- Electric Furnace Brazing
- Resistance Welding

Write or phone your nearest Westinghouse office for details.

When we say automatic welding is *better, faster, cheaper* . . . we can prove it right in our own plants. Westinghouse not only makes automatic welding equipment, we're also one of its largest users.

At Buffalo, automatic welding permitted our designers to accomplish these outstanding results in producing the new LIFE-LINE motor: *size and weight reduced 35% . . . power capability increased 116% per pound . . . parts for complete line of NEMA motors reduced from 2,600 to 128 . . . production tripled.*

Once a setup is made, automatic welding becomes a "pushbutton" operation. Even with relatively unskilled labor, every weld is made perfectly. At last, welding approaches machine tool accuracy and speed of work handling.

Westinghouse is the *first* manufacturer to offer complete, "packaged" automatic welding equipment —built, sold and installed as a unit. A Westinghouse welding specialist is ready now to help you apply this improved metal-joining technique to your assembly problems.

J-85002

Westinghouse

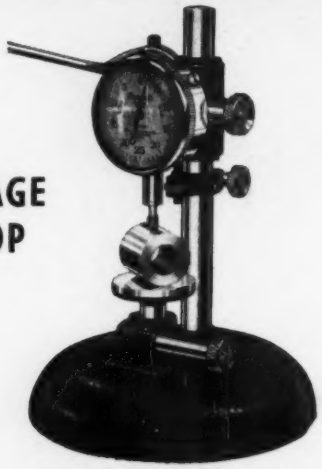
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

MORE PRODUCTIVE POWER FOR INDUSTRY

STARRETT No. 654
INSPECTOR'S DIAL
BENCH GAGE

HANDIEST GAGE
IN THE SHOP

• See it at your tool dealers or write for new STARRETT Dial Indicator Catalog "L"

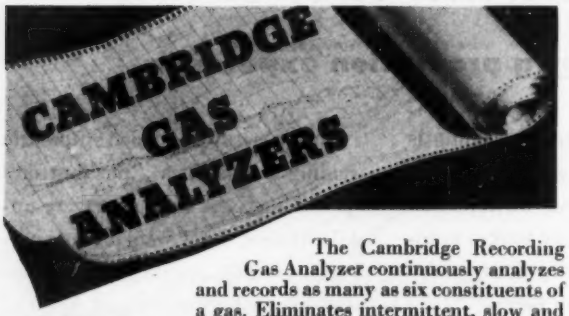


Easy to adjust, easy to use, this STARRETT Precision Bench Gage works full time as a production inspection gage for duplicate parts or for quick, accurate measuring of metal, rubber, textiles, paper, leather, veneer, plastics, mica, etc. Shown with STARRETT No. 25-B Dial Indicator (graduated .0005"; 0–25–0) it can be furnished with any desired indicator. Adjustable for table and indicator height with lateral and fine perpendicular adjustment. Range 0 to 3 inches, base diameter 5½ inches, height 8 inches.

Buy Through Your Distributor

THE L. S. STARRETT CO. • ATHOL • MASSACHUSETTS • U. S. A.
World's Greatest Toolmakers

STARRETT
PRECISION TOOLS • DIAL INDICATORS • STEEL TAPES • GROUND FLAT STOCK
HACKSAWS • BAND SAWS FOR CUTTING METAL, WOOD, PLASTICS



The Cambridge Recording Gas Analyzer continuously analyzes and records as many as six constituents of a gas. Eliminates intermittent, slow and expensive manual gas analysis. Accurate . . . Sensitive . . . Simple. No moving parts; utilizes thermal conductivity principle.

Makes possible substantial savings in the operation of kilns, production of inert gases, and in metallurgical, petroleum, and other chemical processes. Single- and Multi-point instruments are available for a wide variety of applications.

Send for literature;
please mention application

CAMBRIDGE
INSTRUMENT COMPANY, INC.
3707 Grand Central Terminal, New York 17

Pioneer Manufacturers of
PRECISION INSTRUMENTS

THE TABULAR VIEW

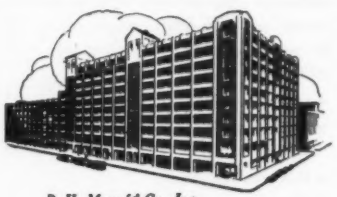
(*Concluded from page 10*)

two years as an instructor in chemistry at M.I.T. from which he received his master of science degree in 1919. During World War I, Mr. Stevenson saw active duty with the Chemical Warfare Service, and during the more recent conflict was chief, Division 11, National Defense Research Committee. Mr. Stevenson has been with Arthur D. Little, Inc. since 1919, and since 1935 has been president of this well-known firm of consultants.

Surface Chemistry. — Writing with the authority of a quarter of a century of research in the field, PROFESSOR ERNST A. HAUSER reminds Review readers (page 36) that the signal successes of this country's rubber industry are dependent upon accurate knowledge of the events transpiring in the microcosms of colloids. After receiving his doctorate from the University of Vienna in 1921 and completing a one-year appointment as assistant to Max Born, Dr. Hauser assumed charge of the research laboratory for the Krause Spray Drying Laboratory in Frankfort from 1922 to 1925. He was head of the Colloid Chemical Laboratories of Metallgesellschaft A. G. from 1925 to 1932 and in charge of research and development of Semperit Austro-American Rubber Works, Ltd. in Vienna from 1933 to 1935. Since 1935, when he joined the Department of Chemical Engineering at M.I.T. as a resident associate professor, Dr. Hauser has continued his outstanding researches in colloidal chemistry and has also found time to take part in activities of numerous professional societies.

Leaving the Portals. — In what will be one of the last "off season" commencement exercises resulting from the accelerated courses offered during the war, 442 degrees were awarded to 439 graduates on September 26. Before departing for professional posts in industry or academic life, members of the Class of 9–47 were privileged to be addressed by PRESIDENT COMPTON whose stimulating commencement address is recorded on page 38.

Speed with
Economy

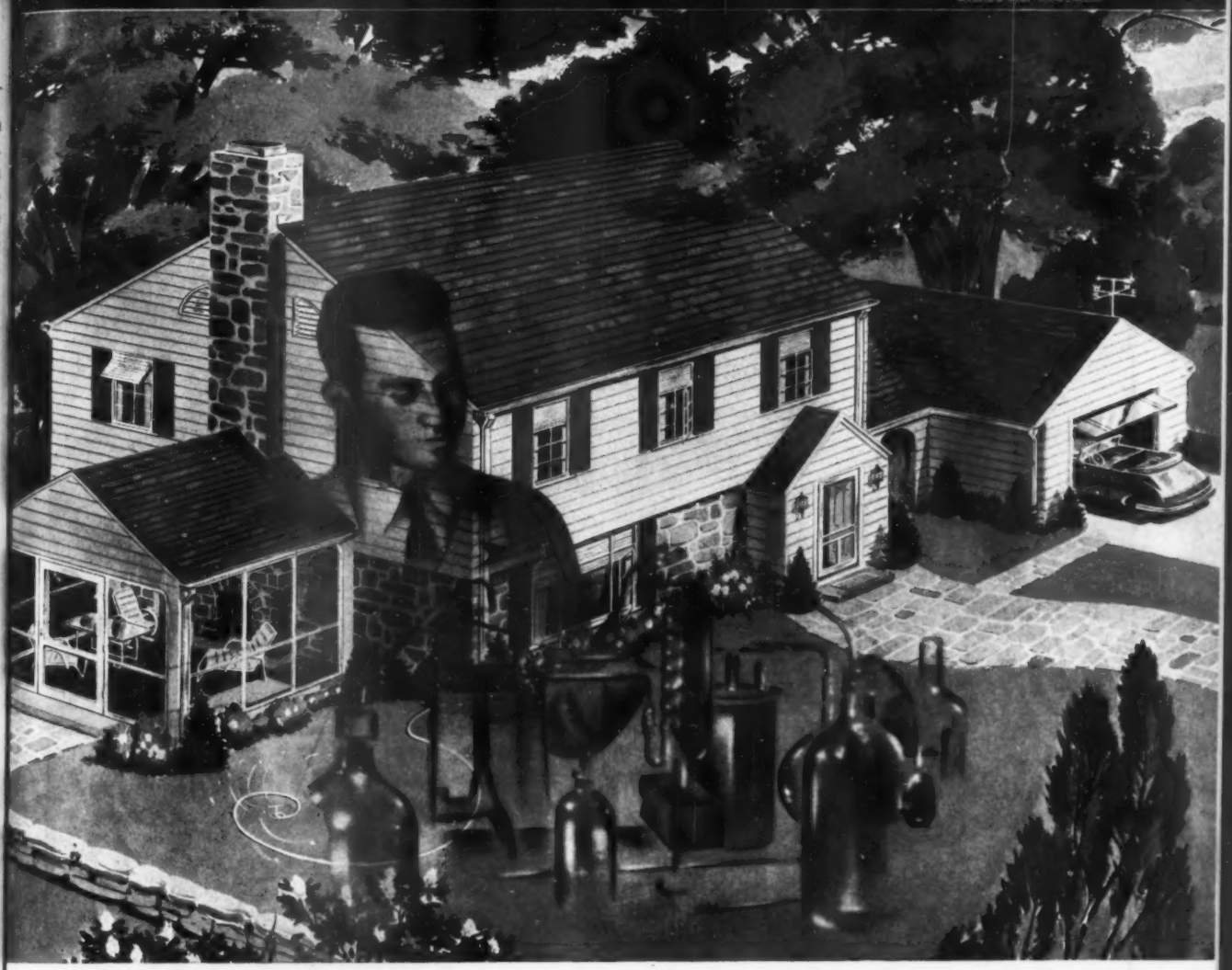


R. H. Macy & Co., Inc.
Warehouse (11 contracts)

Sound construction, speed, economy — have made a large majority of our present contracts repeat orders. Something to remember when you need a new building.

W. J. BARNEY CORPORATION
101 PARK AVENUE, NEW YORK
INDUSTRIAL CONSTRUCTION
Alfred T. Glassett, '20, Vice President

"The great highroad of human welfare lies along the old highway of steadfast well-doing"
—SAMUEL SMILES



Why some homes get better all the time

HOMES, like human beings, need stout "constitutions"... which depend, in turn, on building products used. And these are getting better all the time.

In building or remodeling today, you can choose weather-defiant paint . . . warm-hued and *lasting* plastic tiles for kitchens and bathrooms . . . hardware and window screens of stainless steel or any-purpose plastics.

Yours, too, are heating installations with leakproof welded piping and streamlined plumbing. To say nothing of resin-glued plywood, good for decades as sheathing, subflooring, doors and complete interior and exterior walls.

These are a few of today's countless building products that give better service *because into them go better basic materials.*

Producing better materials for the use of science and industry and the benefit of mankind is the work of the people of UNION CARBIDE.

It takes basic knowledge and relentless research. Tremendous pressures and extreme vacuums. Heat up to 6000° and cold down to 300° below zero, Fahrenheit. Working with these—*and working together*—the various Units of UCC now separate or combine nearly one-half of the many elements of the earth.

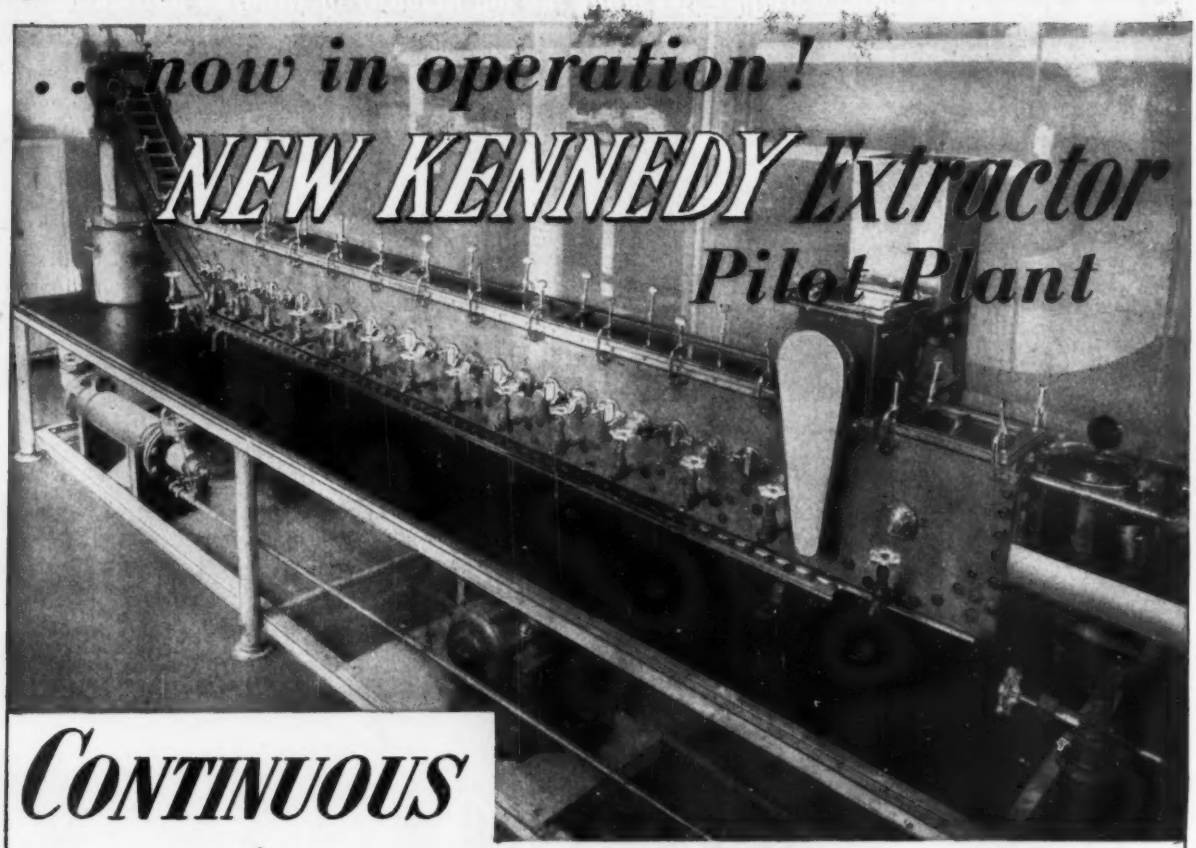
FREE: *You are invited to send for the illustrated booklet, "Products and Processes," which describes the ways in which industry uses UCC's Alloys, Chemicals, Carbons, Gases, and Plastics.*

UNION CARBIDE
AND CARBON CORPORATION

30 EAST 42ND STREET UCC NEW YORK 17, N. Y.

Products of Divisions and Units include

LINDE OXYGEN • PREST-O-LITE ACETYLENE • PYROFAX GAS • BAKELITE, KRENE, VINYON, AND VINYLITE PLASTICS
NATIONAL CARBONS • EVEREADY FLASHLIGHTS AND BATTERIES • ACHESON ELECTRODES
PRESTONE AND TREK ANTI-FREEZES • ELECTROMET ALLOYS AND METALS • HAYNES STELLITE ALLOYS • SYNTHETIC ORGANIC CHEMICALS



. . . now in operation!

NEW KENNEDY Extractor Pilot Plant

CONTINUOUS Counter-Current SOLVENT EXTRACTION

The Kennedy Extraction Division of Vulcan offers complete Solvent Extraction Plants for the economical and efficient recovery of oils, fats and waxes from a variety of vegetable and animal materials.

The Kennedy Continuous Extractor of stainless steel construction is unique in its ability to handle high oil content materials and finely ground products containing excessive "fines". Materials containing as high as 55% oil are readily extracted to less than 1% in a single, continuous operation. This "one step" method of extraction eliminates the costly "fore-pressing" operation. The Kennedy Extractor is also adaptable to many leaching and washing processes.

Complete pilot plant facilities are available for the comprehensive study of special extraction problems. In conjunction with pilot plant operation, the Vulcan laboratories, adequately staffed by chemical engineers and chemists of long experience, are at your service for analytical work. Vulcan design engineers carefully convert pilot plant data to commercial scale design.

Vulcan has the organization to design, fabricate, erect, and initially operate complete plants to successfully overcome all extraction problems.

Complete PILOT PLANT Facilities

VULCAN

DISTILLATION
EVAPORATION
EXTRACTION
PROCESSES and EQUIPMENT

KENNEDY EXTRACTION DIVISION OF

THE VULCAN COPPER AND SUPPLY CO. - CINCINNATI, OHIO

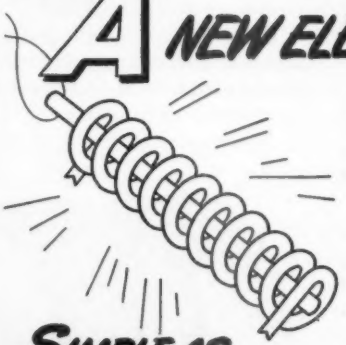
THE MARCH OF SCIENCE

MIRACLE HEAT— without fire or furnace!

HEATING A PIECE OF METAL BY OPEN FLAME, BLOW-TORCH OR FURNACE IS RELATIVELY SLOW— APT TO LEAVE SCALE... IT'S HARD TO HEAT ONE SPECIFIC AREA WITHOUT HEATING THE WHOLE PIECE.

PRODUCTION MEN REALIZED HEAT-TREATING OPERATIONS SUCH AS FORGING, PRECISION BRAZING AND SURFACE HARDENING COULD BE STEPPED WAY UP IF A FASTER METHOD OF HEATING COULD BE FOUND... ONE WHICH WOULD CONCENTRATE THE HEAT AT PRE-SELECTED AREAS!

HEAT BY INDUCTION SEEMED LIKE THE ANSWER. SCIENCE HAD ALREADY DISCOVERED THAT METALS HEAT RAPIDLY WHEN INTRODUCED INTO A HIGH FREQUENCY, HIGH DENSITY MAGNETIC FIELD!



A NEW ELECTRONIC HEATER DESIGNED BY ALLIS-CHALMERS SCIENTISTS—

AMAZING PRODUCTION TOOL RECTIFIES ORDINARY 60-CYCLE CURRENT THEN STEPS IT UP TO 450,000 CYCLES. A MAGNETIC FIELD OF HIGH DENSITY IS SET UP IN WORK COIL AND WHEN METAL IS INTRODUCED INTO THIS FIELD, PASSAGE OF CURRENT CAUSES POWER LOSSES WHICH PRODUCE HEAT WITHIN THE METAL WITH INCREDIBLE SWIFTNESS.

BIG BENEFITS: COMPLETE, SELECTIVE CONTROL OF HEAT PENETRATION... EXACT UNIFORMITY... GREATLY INCREASED PRODUCTION!

SIMPLE AS

A PLACE METAL IN WORK COIL...

B PUSH BUTTON

C METAL IS HOT IN SPLIT SECONDS

ALLIS-CHALMERS MANUFACTURING CO. MILWAUKEE 1, WIS.

ELECTRONIC HEATER IS ONE MORE EXAMPLE OF HOW ALLIS-CHALMERS RESEARCH AND EXPERIENCE GO TO WORK FINDING BETTER, FASTER, MORE EFFICIENT WAYS OF HANDLING PRODUCTION PROBLEMS—ANOTHER GOOD REASON WHY A-C EQUIPMENT IS IN DEMAND IN EVERY MAJOR INDUSTRY...

ALLIS CHALMERS

ONE OF THE BIG 3 IN ELECTRIC POWER EQUIPMENT
BIGGEST OF ALL IN RANGE OF INDUSTRIAL PRODUCTS

DETROIT PUBLIC LIBRARY

Here's the new kind of tire that astonished auto engineers!

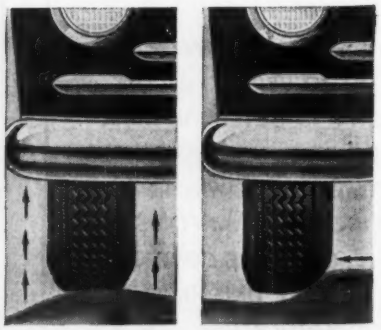
New Super-Cushion by Goodyear is first to absorb lateral shock satisfactorily

Here's what hard-boiled automotive engineers said when they had tested this completely new kind of tire:

"Let's get that tire on our cars *as soon as possible!*"

Why? Because here for the first time was a tire that did what *no* tire had ever done before! It satisfactorily absorbed lateral (crosswise) shocks—one of the few things that still had to be engineered out of the modern motor car. It gave an unbelievably smoother ride—not only on rough roads but even on good ones.

Bigger and softer than the conventional tire, the Super-Cushion builds up less pressure. This means it does not lose its better riding qualities on a long run.



Till Goodyear produced Super-Cushions, lateral or crosswise shock had never been satisfactorily absorbed. Pillow-like Super-Cushions soak up lateral shocks, giving an unbelievably smoother ride.

The engineers found that this bigger tire rolls with the punch! It's a *safer* tire! It *yields* instead of resisting impacts. There's less chance of cutting, bruising, or breaking.

And because it's a softer tire with stop notches *molded* across the tread, you get better traction—and *notice* it when you step on the brakes or gas.

Super-Cushions make a small car feel like a big one. You seem to float in and out of traffic. And they make *any* car safer and easier to handle, especially on turns.

Mileage? In millions of test miles, Super-Cushions *consistently averaged more mileage than the best standard tires!*

The speed with which leading car makers accepted this new kind of tire indicates definitely that it is the tire of the future.

Auto engineers call it the first tire in 15 years to make a positive contribution to driving comfort and safety.

Call on your Goodyear dealer today and find out how you can enjoy the advantages of Goodyear Super-Cushions on *your* car!

The new *Super-Cushion* by GOODYEAR

ALMOST LIKE FLOATING

VOL. 50 No. 1

THE TECHNOLOGY REVIEW

TITLE REGISTERED, U. S. PATENT OFFICE

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

☆ ☆ ☆

Contents for November, 1947

SYMBOLIC • *Photograph by K. B. Clarke from Black Star* . . . . . THE COVER

PATTERN IN MARBLE • *Photograph by S. A. Wagner* . . . . . FRONTISPIECE 20

PROGRESS IN AIR POWER RELATED TO CONSTRUCTION POWER . . . . . *By* WILLARD ROPER 24
Inability to construct adequate airfields economically may restrict the size of tomorrow's aircraft

RESEARCH FOR EDUCATION . . . . . *By* JAMES R. KILLIAN, JR. 29
Contributions which it can make in advancing education underlie the policy of M.I.T. in conducting research

OXYGEN FOR INDUSTRY . . . . . *By* EARL P. STEVENSON 32
High purity, low cost, and large-volume production of oxygen open extensive uses for this important gas

COLLOIDS IN SCIENCE AND INDUSTRY . . . . . *By* ERNST A. HAUSER 36
Smallness of particle size goes hand in hand with the industrial importance of colloid chemistry

SAFELY THROUGH ROUGH WATERS . . . . . *By* KARL T. COMPTON 38
Commencement Address of President Compton to those who received their degrees in September

THE TABULAR VIEW • *Contributors and Contributions* 10

THE TREND OF AFFAIRS • *News of Science and Engineering* 21

THE INSTITUTE GAZETTE • *Relating to the Massachusetts Institute of Technology* 39

☆ ☆ ☆

Publisher • H. E. LOBDELL *Editor* • B. DUDLEY *Business Manager* • R. T. JOPE
Editorial Associates: PAUL COHEN • T. L. DAVIS • J. R. KILLIAN, JR. • WILLY LEY • F. W. NORDSIEK
J. J. ROWLANDS • D. O. WOODBURY
Editorial Staff: THEODORA KEITH, RUTH KING *Business Staff:* MADELINE R. MCCORMICK

Published monthly from November to July inclusive on the twenty-seventh of the month preceding the date of issue, at 50 cents a copy. Annual subscription, $3.50; Canadian and foreign subscription, $4.00. Published for the Alumni Association of the M.I.T.: Raymond H. Blanchard, President; H. E. Lobdell, Executive Vice-president; C. George Dandrow, John A. Lunn, Vice-presidents; Charles E Locke, Secretary; Ralph T. Jope, Treasurer. Published at the Rumford Press, 10 Ferry Street, Concord, N. H. Editorial Office, Room 7-203, Massachusetts Institute of Technology, Cambridge 39, Mass. Entered as second-class mail matter at the post office at Concord, N. H. Copyright, 1947, by the Alumni Association of the Massachusetts Institute of Technology. Three weeks must be allowed to effect changes of address, for which both old and new addresses should be given.

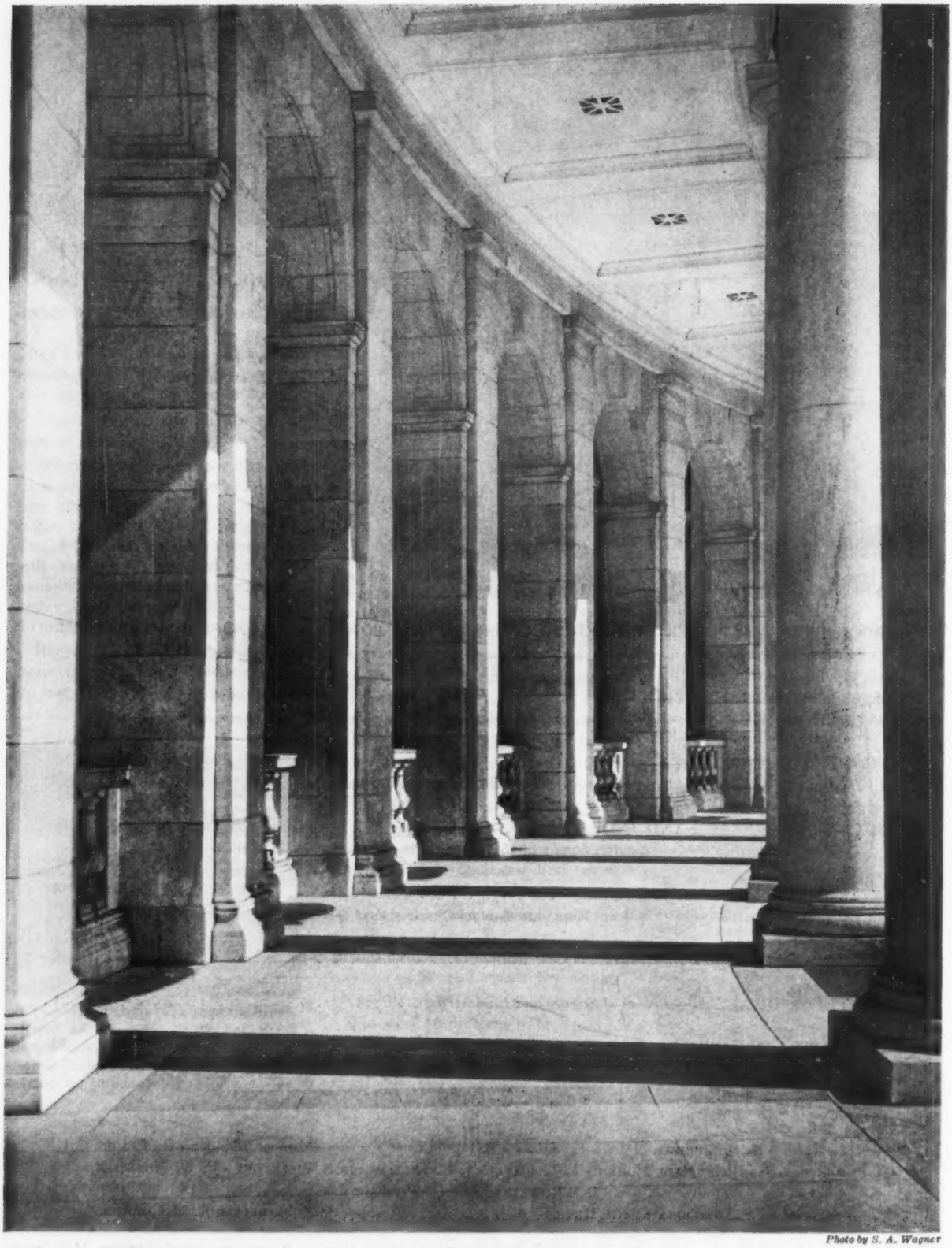


Photo by S. A. Wagner

Pattern in Marble

Photography captures the texture and reflects the character of an architect's drawing in this photograph of a colonnade exhibited last summer in the Technology Photographic Salon.

THE
TECHNOLOGY REVIEW

Vol. 50, No. 1 November, 1947

The Trend of Affairs

Volume 50

RETROSPECTION appears to be called for in inaugurating Volume 50 of The Technology Review. Ordinarily the simple imprint "Vol. 50" would serve to mark the golden anniversary of a publication and proclaim to its readers that a new half-century era was being ushered in. It is not until January 1, 1949, however, that The Review is entitled to celebrate the beginning of its fifth decade as a journal of science and engineering, edited at the Massachusetts Institute of Technology and serving M.I.T. Alumni. Volume 50 occurs earlier than The Review's half-century mark not only because the school year does not coincide with the calendar year, but also because changes in certain publication policies were required in Volume 25 when The Technology Review grew from a quarterly to a monthly periodical.

Earlier volumes record the progress of M.I.T. from "the Tech on Boylston Street" to the present overcrowded institution on the Charles River. Treated with alternate concern and pride are the problems and achievements of successive administrations under presidents James Mason Crafts, Henry Smith Pritchett, Arthur Amos Noyes, Richard Cockburn Maclaurin, Elihu Thomson, Ernest Fox Nichols, Samuel Wesley Stratton, and Karl Taylor Compton. For 49 volumes The Review has rejoiced in the successes of its illustrious Alumni and sorrowfully recorded the passing of some.

The advancement of engineering education also looms large in past issues. In fact, one of the earliest articles was entitled "Methods of Teaching Engineering." Those with a nostalgic temperament will undoubtedly delight in the knowledge that the author of this thought-provoking article was C. Frank Allen, '72, who enjoyed celebrating his 75th anniversary as an M.I.T. alumnus on June 14 last.

When The Review first made its bow to a small group of readers there was already a community "groaning under an ever increasing weight of periodical literature" as the reproduced announcement reminds us. Now, as then, "The Review neither throws itself upon the charity of its friends nor prays them to be blind to its shortcomings." Now, even more than ever, "the Institute obviously stands in need of a clearing-house of information and thought, to increase its power, to minimize waste, to ensure among its

The Technology Review

VOL. I. JANUARY, 1899 No. 1

ANNOUNCEMENT

To a community groaning under an ever increasing weight of periodical literature, a new magazine is forced to present itself in an attitude of apology. Like those college men with whom its interests are to be most closely bound, THE TECHNOLOGY REVIEW must make plain its purposes, its capacity, its determination to be useful, before it can expect to receive recognition from a public too busy to be indulgent. Realizing this, and mindful, too, of the spirit and traditions of the Massachusetts Institute of Technology, THE REVIEW neither throws itself upon the charity of its friends nor prays them to be blind to its shortcomings. Doubtless it will need indulgence, doubtless its attainment will fall much below its aspiration; but if it does not so far succeed in its attempt as to gain support through feelings other than those of simple friendliness, the existence of THE REVIEW cannot be too quickly ended.

Few appreciate how vast and complicated the interests of the Massachusetts Institute of Technology have become. With students, past and present, in every State, and in almost every part of the world, occupied in all manner of work and every civic duty; with studies of great range and courses of wide divergence; with always new and ever more complex problems of education crying for solution, the Institute obviously stands in need of a clearing-house of information and thought, to increase its power, to minimize waste, to ensure among its countless friends the most perfect coöperation.

countless friends the most perfect co-operation." We take pride in reaffirming: "Such a clearing-house The Technology Review purposes to be."

Replenishing the Intellectual Flesh

TIME for reflection and for the development of a more rounded personality on the part of those engaged in scientific research was given new impetus by Charles A. Thomas, '24, in an address made this summer before the Industrial Research Institute, Inc. The highly specialized character of much of modern research has tended to departmentalize thinking of the individual into narrow, restricted fields, with consequent oversight or neglect of the significance of his work and its effect on the world's people. World War II has not only emphasized specialization in research but has added other detrimental effects which Dr. Thomas feels must be combated.

Physical destruction and moral disruption have brought about a serious decline in the field of science in European nations. The United States can no longer look to other nations, as it did in the past, for fundamentally new scientific knowledge — for the spark of an idea which American genius can blow, tender, and fan into a great fire. The originality and creativeness of American research must be stimulated to new heights if the gap created by the European decline is to be bridged.

The businesslike, highly specialized laboratory is an industrial necessity, but it does not appear to have provided that environment for bringing into being the basic scientific conceptions. There may have been so much formalizing and organizing of the laboratories as to bring about an overemphasis on equipment and facilities and an underemphasis of the men who are, after all, the creators. It is the men who make the laboratories, and not the other way around.

Many industrial scientists are depending on what might be termed their "intellectual fat," for under the stress of modern industrial living, they have no time to replenish their intellectual flesh. Nor does it seem that this criticism is directed specifically and alone to industrial scientists, at least for the present.

As one means of counteracting this deficiency of our industrial way of life, Dr. Thomas proposes that the more progressive key men in modern laboratories organize their programs and distribute their responsibilities to subordinates so that, at least for a period of a few weeks every year, they could absent themselves from their regular duties for personal development and exploration of stored-up ideas. Such time would be spent as the men wish — in libraries, in other laboratories, or in the comparative quiet and seclusion of the country. Such time should be reserved for their personal intellectual development in much the same way that the usual two weeks' vacation is customarily set aside for physical relaxation and development; it would be a period during which the accumulation of unworked but promising ideas might be investigated, fertilized, cultivated; from which, possibly, some beneficial results might be reaped. It would be a period for which the research worker would read the literature in his own and related fields; it should also be one for investigating foreign fields, so that these men may derive stimulation from the thinking which is being done in spheres with which they normally have little contact. In short, Dr. Thomas proposes for the research worker in industry a "sabbatical leave of absence" which was once not unknown in the academic field for just such purposes, but which, unfortunately, seems to have lost much of its vogue under the pressure of recent events.

Kudos for Teaching

PROFESSORS A. A. Knowlton and Clifford N. Wall have received honors of more than ordinary significance: for their outstanding undergraduate teaching of physics, respectively, at Reed College, Portland, Ore., and North Central College, Naperville, Ill. Bronze plaques and honoraria were presented to them last month on behalf of the Research Corporation of New York City by its president, Dr. Joseph W. Barker, '16.

Research Corporation awards for research were customary before the war. Such new international figures as Dr. Vannevar Bush, '16, and Professors Ernest O. Lawrence, of the University of California, and Percy W. Bridgman, of Harvard, received them. Two such awards for 1947 are to be presented this month for wartime accomplishments to Dr. Lee A. DuBridge, now president of the California Institute of Technology, and Dr. Merle A. Tuve, of the Carnegie Institution of Washington. The former, it will be recalled, was director of the Radiation Laboratory at M.I.T., and Dr. Tuve's recognition comes for his work at the Applied Physics Laboratory of the Office of Scientific Research and Development at Johns Hopkins University.

The special awards to Professors Wall and Knowlton, the former of whom is now on the faculty of the University of Minnesota, derived from studies made by Dr. M. H. Trytten for the National Research Council on the education of doctors of philosophy in the physical sciences. Two small institutions stood out for producing students who, after taking their bachelor of science degrees in physics, went on to compete successfully for the doctorate in that field; and further investigation at those institutions pointed to Professors Knowlton and Wall as the responsible inspiring teachers.

These two awards for teaching are notable, however, not merely because teaching accomplishment in the field of science — or, for that matter, in other fields — is marked less frequently by medals than is research accomplishment internationally or nationally. Instead, the awards direct attention upon the simple fact that research accomplishment depends primarily upon educating men to make it. Unlike the prewar days, no longer can we depend, for much of our technological advance, upon the fundamental scientific researches made in Europe. The memories of the recent years, when the instruction of students in scientific fields had to give way, possibly rightly, to military necessity, are too fresh to require elaboration here.

Large research laboratories are now in great favor by government, industry, and the universities. We talk of a National Science Foundation and $80,000,000 a year for the support of research by government, in addition to the sums already spent for research by government and other agencies. Where are the really qualified scientists coming from to man these laboratories in the future? Obviously, they are to be developed as a result of the earnest efforts of teachers like Professors Knowlton and Wall, encouraged by understanding givers of kudos such as the Research Corporation.

Atomic Power for Industry

ESTIMATES vary as to the time when engineers can put into practical application, in the building of plants for the production of atomic power for industrial use, the knowledge painstakingly being gained by physicists. No less authority than David E. Lilienthal, chairman of the United States Atomic Energy Commission, has made the statement that the industrial exploitation of atomic energy could not be expected in the near future. Nevertheless, the problem continues to receive every possible consideration, as it has by competent scientists long before the public became aware of the importance of atomic power.

Indicative of the widespread importance of this project, and of this country's desire to advance as rapidly as possible the industrial potentialities of atomic power, is the recent appointment by Mr. Lilienthal of a group of seven outstanding industrial leaders to serve as a board of consultants for the Atomic Energy Commission. Charged with the responsibility to speed up the industrial opportunities in the field of atomic power, the new board of consultants includes the names of Donald F. Carpenter, '22, Vice-president of the Remington Arms Company, and Robert E. Wilson, '16, chairman of the board of Standard Oil Company of Indiana. The board is to serve as a means of contact between the Atomic Energy Commission and creative thinkers in this country and, indeed, throughout the world. Emphasis is to be placed on the full use and development of the initiative and inventive genius of private enterprise.

Ideal By-Product

WASTE materials from food processing may be either a liability or an asset to the processor. Food wastes are liabilities when they are discarded; haulage for dumping is costly, and direct discharge into the local sewerage may be forbidden or may be permitted only at the price of monetary penalties. Such restrictions are necessary because industrial wastes are much more concentrated than is domestic sewage, and correspondingly overtax municipal sewage disposal facilities. For example, on the basis of biochemical oxygen demand, suspended solids, and nitrogen content, 139 food-manufacturing plants located in the sanitary district of Chicago discharge wastes equivalent to the sewage resulting from more than 1,800,000 people — a population nearly half as large as that served by the sanitary district.

But the wastes of food processing become assets when they are treated (usually dried) so that their nutritive or other values are salvageable. Unfortunately, however, equipment for by-product processing is costly, and obviously returns from the sale of by-products must support this investment. A single plant may not produce enough of the by-product to justify waste-processing equipment. In this situation the waste material may be collected, as by means of tank trucks, for processing at a central point. Examples of this procedure are the collection of whey, from scattered cheese factories, for drying, and the collection of yeast, from small breweries, for debittering and drying.

Industries, such as those of fruit and vegetable processing, that operate only a short time each year, have difficulty justifying investment in by-product processing equipment, because such equipment is idle during the large proportion of each year when these plants are closed.

The background information just outlined shows why one recently developed by-product — tassels from the growing of hybrid seed corn — may be characterized as "the ideal by-product." Dried corn tassels are valuable not only as an adjunct to poultry feeds, wherein they serve as a source of protein and vitamins, but also because they may be processed in equipment always found on seed-growing farms, and otherwise idle at the time when tassels become available.

Hybrid corn is designed to take advantage of the genetic characteristic known as "hybrid vigor"; it is the first generation cross of two inbred strains. To produce the seed, two rows of plants that serve as male parents are planted alternately with six rows of plants that function as female parents. Cross-pollinating is done by hand; to prevent self-pollination the tassels must be removed from the female functioning plants before pollen begins to shed. Production of hybrid corn seed in the United States is so extensive that approximately 50,000 tons of tassels, dry basis, are available annually.

To produce a nonputrescible, marketable product, corn tassels must be dried. But seed corn also is dried before distribution, and the seed driers available on all seed-growing farms are idle during the detasseling period. These driers are entirely suitable for tassel drying. Extensive analyses of corn tassels by one of the Federal Government regional research laboratories have shown that tassels have even higher protein content than has whole grain corn, and are rich in vitamins of the B complex and in carotene (the precursor of vitamin A). Furthermore, these studies showed that the tassels have higher nutritive value at normal detasseling time than earlier or later. Thus, corn tassels, dried and sold for use in poultry feeds, have become an asset instead of a liability to seed-corn growers, and are in fact an ideal by-product.

Techni-Topics

OF COMPARATIVELY recent origin is a projection cathode-ray tube for demonstrating before groups of persons the intricate traces of electric phenomena seen on the fluorescent screen at the end of the oscilloscope tube. Such a projection tube has considerable potential application in the classroom where electrical phenomena can be seen simultaneously by scores of persons instead of perhaps half a dozen as is true with direct-viewing tubes. The educational possibilities of the tube are easily demonstrated by combining the image from it with that of a set of orthogonal axes from an auxiliary projector. The two simultaneously projected images provide a means for representing time varying phenomena in three dimensions. By means of special signal voltages, applied to the deflecting plates of the cathode-ray tube and combined with the usual scanning signals to displace the electron beam, an illusion of traveling waves in three dimensions may be clearly depicted. No doubt considerable development work still remains before the underlying principles can be applied generally to the three-dimensional representation of electromagnetic radiation, mechanical stresses and strains, and other space phenomena which are difficult to visualize. Nevertheless, the possibilities of such a system for (*Concluded on page 64*)

Drawing from Fairchild Aircraft

Progress in Air Power Related to

IN the pioneer days of flying, when airplanes were little more than powered kites, the selection and development of airfields were simple problems and exercised little influence on the newborn technology of flight. For the Wright brothers' first successful venture, the sandy beach at Kitty Hawk was eminently satisfactory and construction effort was limited to the removal, by hand, of some minor debris which, otherwise, might have interfered with the landing gear of the plane.

Balance of Power, World War I

Even with the advent of the military use of airplanes in World War I, the development of areas from which to fly remained a relatively minor factor in the application of air effort. Airfields were developed merely by improving flat well-drained sites by hand labor at a relatively small expenditure of man-hours, materials, and other construction means. Similarly, during World War I, practically all road construction and repairs were accomplished with hand tools. However, in the years just preceding World War II, the enormous strides made by the automobile industry in the design and mass production of trucks in unprecedented numbers, created a situation wherein motor transport became out of balance with the development of road-construction machinery. Under traffic of hitherto unheard of weight and intensity, roads repeatedly became bottlenecks over which long, congested columns of troops, transport, and impedimenta crawled and bogged down while engineer troops toiled and sweat to quarry, hand place, and hand spread sufficient rock. It is significant, therefore, that mobility was lost to the armed forces and a static war of attrition on a fixed front resulted.

Expanding Construction Power

The period between World War I and World War II was marked by rapid technological advances in many fields. Within the construction industry there ensued a tremendous impetus in the design and manufacture of construction machinery, which arose primarily from the public need for high-speed, all-weather highways to support the growing volume of motor vehicle traffic. This construction machinery, created primarily to build our national road net, greatly facilitated the construction of levees, dams, waterways, power installations, and flood control works, the cost of which, on a broad scale, had been prohibitive in the past. By the development, during this period, of the bulldozer, the Diesel-powered shovel, motor patrol, and similar equipment, the cost of such construction was reduced to from one-third to one-fourth of its cost prior to World War I.

This advance in the design of earth-moving machinery had another application in making feasible the construction of commercial airports which were required to support the expanding aircraft industry. Because they appreciated the capacity of the construction industry to create strong and durable pavements, aeronautical engineers were able to proceed with the design of increasingly heavy aircraft, knowing that runways would be made available to support them. Yet, between the two World Wars, only the most visionary engineers could have foreseen the far-reaching effect which the commercial development of construction equipment would have on the ascendancy of air power during the conflict to begin during 1939.

At least a few persons realized the extent to which air power depended on construction power. In a book written about the Air Force just prior to World War II,* General Henry H. Arnold, the wartime commander of the Army Air Forces, and General Ira C. Eaker, pointed out that air

* *Winged Warfare* (New York: Harper and Brothers, 1941), $3.00. See Chapter 3.

That aeronautical engineering is already influenced by problems in the construction of airfields, rather than by aerodynamic factors alone, is indicated by the experimental Fairchild Packet, C-82 (above) whose track-type landing gear is designed to distribute the load of the heavy plane on the ground.

Official Photo U.S.A.A.F.

to Construction Power . . . By Willard Roper

power depended on three major factors: (1) a high type of personnel; (2) the airplane as a weapon; and (3) air bases from which to fly. As the concept of air power grew during the years immediately preceding World War II, it became increasingly evident that air bases would be needed in vast numbers; air bases which could be constructed rapidly and yet be large and heavy enough to support the heaviest airplanes then contemplated and with facilities to provide for repair, refueling, and bomb loading, as well as for the housing of the crews required to fly and to service the aircraft.

Thus it was that in 1940, at about the same time that President Roosevelt called for manufacture of 50,000 military aircraft annually, the Air Force organized the 21st Engineer Aviation Regiment at Langley Field, Va., to serve as the pilot model for many similar air-base construction units to follow. The organization of the regiment was based on concepts developed by the Chief of Engineers, United States Army, for the application of commercial construction equipment to military usage. Although the equipment then selected was considered by military leaders to be extremely heavy for military use, it developed later that even heavier types were needed. As a consequence, for example, R-4 and D-7 tractors gave way to D-8's; three-eighths-yard shovels were replaced by three-quarters- and one and a half-yard; one and a half ton dump trucks gave way to four-ton trucks and 12-yard tourna-trailers. These changes in equipment evolved during the war years as airplanes increased in size from that of the B-18 through the B-17 and B-24 to the B-29, and gross weights rose from less than 35,000 pounds to more than 130,000 pounds.

As a B-24 Liberator returns to base, aviation engineers roll the asphalt in preparation for the arrival of a fleet of B-29's (above). The degree to which future progress in aeronautics depends on advances in construction engineering was amply demonstrated by large bomber operations during World War II.

During World War II, construction power, applied to the construction of air bases by more than 100 aviation engineer battalions all over the globe, exerted a marked influence on the attainment of final victory by making it possible to bring the full weight of our air power to bear against the enemy rapidly and effectively, when and where it was needed most. A somewhat less evident effect of this construction power was that it made possible, indirectly, the development of very heavy bombers by eliminating the limitation normally imposed by the strength of runway pavements.

Balance of Power, World War II

Conversely, one of the principal reasons for the failure of the Japanese to develop heavy bombers, was their lack of construction machinery to create, rapidly, the runways necessary for the support of heavy aircraft loads. It is interesting to note that among the messages sent by General MacArthur to the Japanese authorities, after initial armistice terms had been dictated, was a directive for the Japanese to provide 10 motorized road graders at Atsugi airdrome coincident with the arrival of initial airborne elements of our occupational forces. The Japanese respectfully replied that it was impossible for them to comply with this particular order as there were known to be in operation only three such graders in the entire Japanese Empire and these were not of the self-propelled type. Even the Germans, with their technical skill, lacked the heavy military construction forces necessary to support a modern air force, and the lack of sufficient heavy air bases, when and where needed, was an important factor in the defeat of the Luftwaffe.

Air-base construction power during World War II manifested its support of United States forces in several different ways. First, it permitted the development, within amazingly brief periods of time, of vast numbers of fighter and transport airfields in support of fast-moving, tactical situations. During the campaign which began

Photo by Army Air Forces

CONTRAST IN . . .

Hundreds of powered shovels were transported to island bases during the war for use in the construction of air bases. Ranging in size from one-half cubic yard to two cubic yards, such shovels were larger than construction equipment previously used.

with D Day in Normandy and ended with V-E Day in Berlin, the Aviation Engineers of the Ninth Engineer Command put into operation on the continent of Europe a total of 250 air bases — an average of one every 36 hours. This network of air bases permitted rapid forward deployment of tactical air power in support of the ground armies and, when used additionally for supply and evacuation, made possible such spectacular mechanized advances as that of General Patton's Third Army.

A second type of construction operation which contributed greatly to the advancement of air power was demonstrated in Burma where air-borne aviation engineers landed behind Japanese lines and there developed air bases which advanced the combat lines by hundreds of miles without recourse to long, arduous, and costly jungle campaigns. This same type of operation was utilized to advance our forces along the north coast of New Guinea and through the islands of the Central and South Pacific, except that movement of the construction forces was accomplished by sea instead of by air. The by-passing of large Japanese garrisons would never have been feasible, had it not been for our ability to construct highly developed air bases rapidly at the point of amphibious landing.

The third, and in many ways the most impressive, type of construction undertaking was the development of massive air bases for the support of B-29 operations against the Japanese homeland. Because of its size and weight, the B-29 demanded unprecedented efforts in airfield construction. Its wheel load was 67,500 pounds to the Liberator's 33,900; its gross weight, 135,000 pounds to the Liberator's 67,800. It required a runway 200 feet wide and 8,500 feet long — an area almost twice as great as the 150 by 6,000-foot strips used by Liberators. Other base facilities were in the same proportion. At Saipan, for example, the final stage of development called for two parallel runways with 150-foot shoulders; six miles of taxiways 60 feet wide; two 300 by 1,950-foot service aprons (each as large in area as many fighter strips used in the early days of the war); 180 hardstands, 140 feet in diameter, and 390,000 square feet of warm-up aprons. For this construction about 30,000,000 square feet of land was cleared and graded and, of this area, about 10,000,000 square feet was paved. In addition, gasoline storage for 188,000 barrels of aviation gasoline was required; also required were ammunition storage for 20,000 tons of bombs and all facilities to accommodate the 16,000 individuals who made up the ground and air crews. Despite the vast size of this project, some idea of which may be obtained from the statistical data in Table I (page 28), the base was made ready for the arrival of B-29's, through the efforts of four engineer aviation battalions, within 114 days after the assault landing.

...CONSTRUCTION

In China, where manual work replaces mechanization, construction is slow and costly. The tops of conical towers of earth indicate the original surface of the ground, and were used as a yardstick to compute the amount of material excavated.

Official Photo U.S.A.A.F.

The achievements of American construction power are high-lighted by comparing this project at Saipan with another project which was nearing completion at about the same time in China. There, under American supervision, a staging field was built by Chinese labor for the refueling of India-based B-29's en route to Japanese targets. Without any modern equipment, a construction force was organized to include 60,000 workers hauling baskets of gravel a distance of eight miles; 35,000 more workers crushing stone with hand hammers, and another 5,000 workers pushing wheelbarrows. As many as 200,000 baskets were brought into use at one time, slung on carrying sticks which were bent almost double as the men, and women, worked 12-hour shifts. Even at the prevailing wage rate of $0.11 per day, construction of air bases by these methods was expensive and exasperatingly slow.

Future Trends and Limitations

The kind of construction power which gave the Army Air Forces mobility and striking power during World War II was applied in behalf of the ground Armies and the Navy with equal effectiveness. Roads, bridges, railroads, ports, depots, and repair facilities were constructed rapidly in support of our forces in all parts of the world and gave to the Army and Navy flexibility, speed, and power which were impossible of attainment during World War I. The unbalanced condition of the earlier conflict had given way to one wherein construction capabilities were equal to the task of supporting mobile forces.

Future trends in requirements for construction support of air power can be predicted only with limited accuracy. However, it appears that a point may be reached where air power will be threatened by a new limiting factor, namely, the ability of the civil engineer to support, on the ground, the heaviest aircraft which the aeronautical engineer can support in the air. When airplanes are designed that cannot be supported by runway pavements without enormous outlays of money, man power, materials and machinery — and especially time — then the design of airplanes and the design of airdromes will be out of balance. If a solution is not found, the future mobility and flexibility of air power itself will then be threatened. The development of the B-36, with a gross weight of 300,000 pounds, has given rise to many difficult construction problems; yet even heavier aircraft are in the offing. Aircraft manufacturers believe that the man-hours per pound required to construct an airplane, and the cost per ton-mile to haul pay load, are still on the downward trend with aircraft weighing up to 800,000 pounds.

From the results of recent pavement tests, it is estimated that reinforced concrete pavement, 20 inches thick, will be required to support B-36-type operations.

TABLE I. AIR-BASE CONSTRUCTION AT SAIPAN

Over-all Construction Data Covering Total Work of Engineer Aviation Battalions, Saipan

June 26, 1944 — February 1, 1945

EARTH MOVING: Grand Total	4,433,315 cu. yds.
By carryall scrapers and bulldozers	1,387,817 cu. yds.
By Tournapull	675,785 cu. yds.
By dump trucks (earth)	186,882 cu. yds.
By dump trucks (base coral)	2,102,831 cu. yds.
By dump trucks (asphalt)	80,000 cu. yds.
Coral surfaced areas	3,866,680 sq. yds.
Paved areas	11,000,000 sq. ft.
Building construction (floor space)	1,053,774 sq. ft.
Bulk aviation gasoline (storage capacity)	7,919,000 gals.
Pipe line, aviation gasoline	62,083 ft.
Asphalt produced	127,332 tons
Portland Cement poured	4,142 cu. yds.
Oil or cutback asphalt laid (as dust palliative)	379,648 gals.
Aggregate produced	31,273 cu. yds.
Coral quarried (other than from runways)	2,326,970 cu. yds.*
Explosives used	861,000 lbs.
Mogas fuel consumed	1,721,439 gals.
Diesel fuel consumed	1,349,828 gals.

** Difference between this figure and total coral hauled was furnished individual units for their own construction.*

TABLE II. COMPARATIVE COST OF CONCRETE FOR HEAVY BOMBER AIRFIELDS

Type of Aircraft	*Square Yards of Concrete Required*	*Barrels of Cement*	*Cost to Put Concrete in Place*
B-24	233,300	87,486	$ 691,000
B-29	515,846	257,922	2,217,000
B-36	933,100	466,549	5,759,000

Cost figures are for concrete to build one runway, taxi way, apron, and hardstands, and do not include costs of any housing, bomb storage, sewage disposal, water and gas storage, hangars, or other facilities which, for a B-29 wing field, are comparable in size to a city of 16,000 population.

TABLE III. CONCRETE REQUIREMENTS FOR A B-36 AIRFIELD

	Tons	*40-Ton Railroad Carloads*	*Four-Ton Truckloads*
Cement	93,309	2,332	23,327
Sand	186,619	4,665	46,654
Aggregate	373,239	9,330	93,309
Totals	653,167	16,329	163,291

With 45 four-ton trucks per battalion, each hauling 10 loads per day, it would require 362 days or one year to move the concrete alone on a one-runway B-36 airfield.

Furthermore, partially stabilized runway shoulders will no longer suffice since, if a heavy bomber of the B-36 type rolls off the pavement, even when taxiing, serious damage is very likely to result. Table II gives some indication of the relative cost of building a single runway air base for B-36, B-29, and B-24 aircraft, although only costs pertaining to concrete are shown, and costs pertaining to grading, base course, and other airdrome facilities have been excluded. It is apparent that the cost of pavement only, for a B-36 field, is approximately nine times the cost of a similar B-24 installation and two and a half times that for a B-29. From a military standpoint, however, even more important are the logistical difficulties which would be encountered in construction of such a base in time of war. From Table III, which shows the weight of materials involved for concrete pavement only, it may be seen that 20 Victory ships would be required to move the cement alone in constructing a single runway for B-36's. Therefore, the practicability of effecting rapid construction of B-36 air bases by current methods in time of war is at least open to question.

It is certain that a solution to these problems must, and will be, found. We may wish and hope that very heavy bomber bases could be restricted to the United States. Still, the natural tendency to push air bases as far forward as possible, in order to be within fighter-escort range or to drop more bombs more frequently, would be experienced in any future conflict, just as it was manifested during World War II. In solving our present difficulties, however, a situation is encountered which is quite different from that which existed after World War I. This important difference is the lack of a nationwide economic impetus for developing heavier construction machinery and methods to produce surfaces for high-speed traffic loads, such as is imposed by the B-36.

Track-Type Landing Gear

One solution appears to lie in the development of landing gear which will provide greater load distribution and hence permit operations from less highly developed surfaces. Multiple wheel landing gear, that is, twin, twin-tandem, and spaced-tandem arrangements, afford some measure of relief but add additional weight to the aircraft and are subject to limitations imposed by tire design. Tire inflation pressures up to 170 pounds per square inch are now used in some of the newer aircraft and possibly these may be raised to 300 pounds per square inch. The effect of such inflation pressures, however, will be to cause extremely heavy damage to all but the highest type of pavement surfaces.

Recently the caterpillar type track, commonly used on tractors, tanks, and half trucks, has been adapted, experimentally, for use on aircraft. A continuous, smooth, outer-surfaced belt, rolling on, and supported by, suitably spaced bogies assembled into a landing gear already has been used successfully on an A-20 light bomber and is being tested on a C-82 Fairchild Packet. With this gear, test runs have shown the feasibility of landing, taxiing on, and taking off from ground which would bog down any standard gear. Utilization of this type gear would greatly simplify the problem of effecting air-borne landings in hostile territory and, if applied to the very heavy aircraft of the future, would reduce air-base construction requirements enormously.

In the initial stages of development, it appeared probable that the flexibility of the belt of the track landing gear between bogies would make the gear inoperative on hard surfaces; a condition which might well have revolutionized pavement design. That is, an airplane so equipped was able to land on a soft field, but could not land safely on a hard one. Recent design changes indicate this limitation probably can be removed, thus permitting airplanes with track-type gear to operate from existing hard-surfaced runways. However, (*Concluded on page 58*)

Research for Education

Advancement of M.I.T.'s Educational Objective Is Primary Factor Governing Acceptance and Priority of Sponsored Research

By James R. Killian, Jr.

RECALLED by all is the "long hairs vs. hairy ears" argument that followed World War II, and the repeated assertion that men trained in science, especially in physics, proved to be more effective at applied research than did the engineers. No doubt this assertion, if analyzed, can be shown to be a half-truth. Nevertheless, the half-truth that remains should force and is forcing a re-examination of some of our methods and procedures in engineering education, and of our use of research as a method of teaching.

The scientists ascribe their success in handling applied research during the war to several factors: The first is that they had advanced training and most of them held doctor's degrees. The second is that they had a fundamental training in science that was both broad and deep, with the result that they were able to bring to bear upon practical problems a wide range of scientific learning and a flexible method of thinking. The third is that the training which they had received and the environment in which they had worked promoted creative thinking of a quite untrammeled kind. They were not normally concerned by any practical or economic limitations and they were instinctively inclined to dream and speculate, with a bold indifference to limitations. Such unusually favorable conditions for research have seldom occurred before.

Now this kind of training and this point of view are not a monopoly of the scientist, and there are fields of engineering which have embraced them for many years. The fact remains that engineering, while retaining its capacity to work under practical limitations, must at the same time adopt more of the analytical tools of pure science and its willingness to question standard practice. The feeling is widespread in many institutions that research must be used throughout our engineering training to attract men of imaginative minds and to train engineers who have the temerity and capacity to dream and speculate beyond the boundaries of the immediately practical.

The engineering departments at M.I.T. have long been wedded to the principle that research and the research atmosphere are essential to the training of both undergraduates and postgraduates and that a balanced staff must involve creative competence as well as teaching competence. No doubt this tendency to deepen engineering education through stressing fundamental research is one of the most important changes now in process. While engineers must always maintain their firm hold on the economic and applied aspects of their art, they can enormously benefit by promoting within their ranks an increasing number of scholars with the courage to ignore conventional conceptions and with a comprehensive understanding of physical laws and analytical methods.

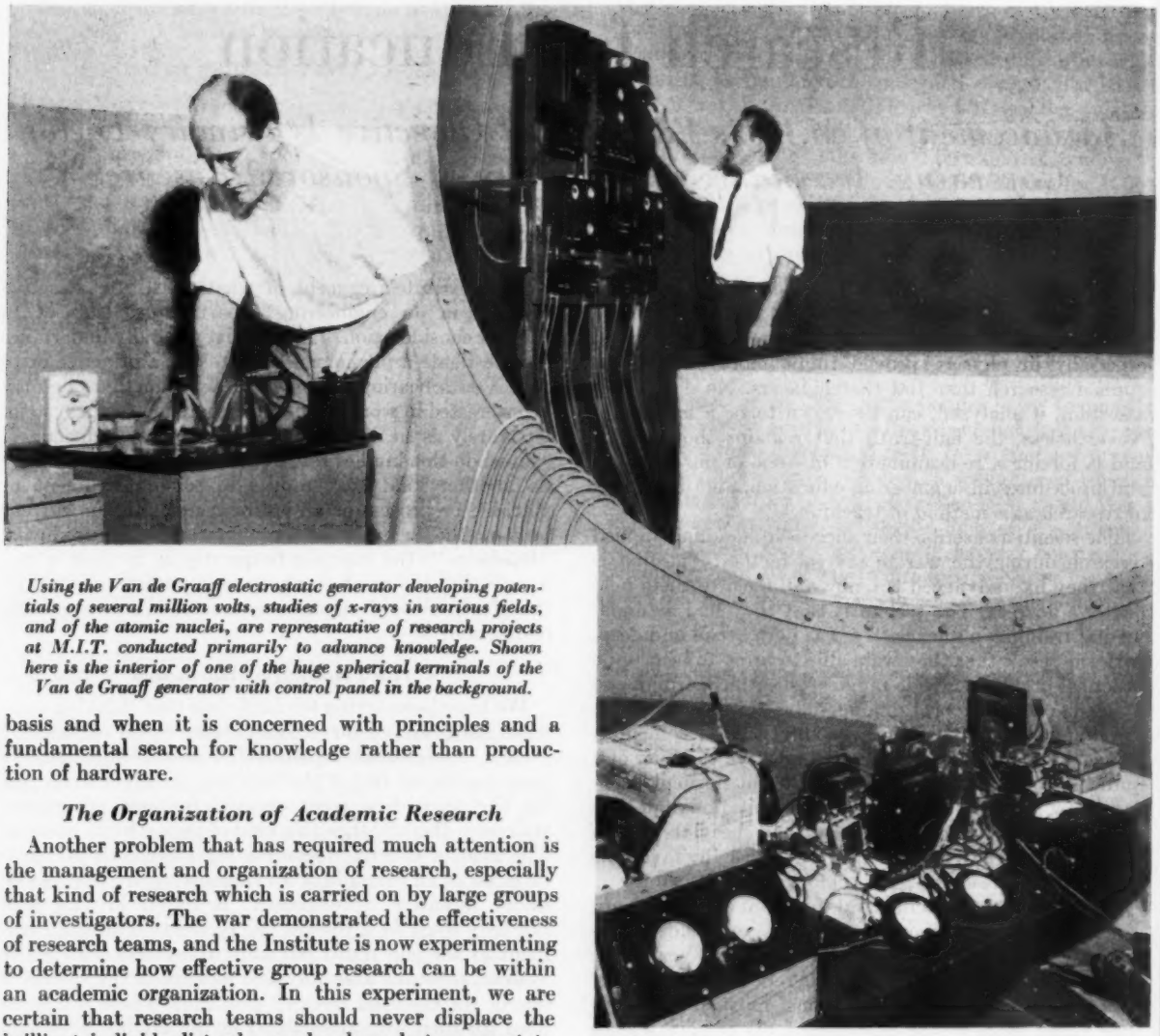
The Institute's concept of what constitutes effective research in an engineering department is subject to another consideration. The scientist generally undertakes to investigate a phenomenon or to seek a principle or to collect data bearing on a hypothesis. Sometimes he may be interested in working on some component of a system, but rarely is he interested in a system. Engineers, of course, do this kind of research, too, but frequently they do another kind that results in some instrument or machine or process or an entire system. In the current jargon, the scientist is not interested in producing "hardware"; the engineer frequently is. Is there a real danger that too much emphasis on hardware may reduce the effectiveness of engineering research in an educational institution?

The Problem of Hardware

We have been trying to clarify our own thinking as to when hardware, or the design of some entire engineering system, does provide a justifiable research objective. We have concluded that if the hardware involves some new art and there is a great demand for men adequately trained in this art, then this kind of research can be vital. The field of control (including servomechanisms), may be cited as an example of an engineering art that is still under intensive development. Research in this field not only must look toward the production of an instrument as the end result but must comprehend an entire system, since the assembly and balance of the system is one of the essential research problems. There is a great need for men who are trained in the art of developing dynamic control systems, and consequently any laboratory activity must deal with the over-all system.

This emphasis on system research in the control field justifies another type of research which might commonly be out of place in an engineering institution, that is research which involves the production of equipment. In control, and a few other fields, because of the importance of the systems aspect, the production of equipment involves a new art and a research technique which is essential in training men in the field at an advanced level. There is no way for these men to become effectively trained other than to work on a project which involves the production of control units. More importantly a systems project or the engineering of a piece of equipment can be an extraordinarily effective educational vehicle by requiring a synthesis of all that the student has learned.

At M.I.T. we believe that research or hardware or systems should meet these tests of educational validity. With these exceptions in mind, we believe that engineering research in an educational environment can be most effective when it is handled on a component, or unit,



Using the Van de Graaff electrostatic generator developing potentials of several million volts, studies of x-rays in various fields, and of the atomic nuclei, are representative of research projects at M.I.T. conducted primarily to advance knowledge. Shown here is the interior of one of the huge spherical terminals of the Van de Graaff generator with control panel in the background.

basis and when it is concerned with principles and a fundamental search for knowledge rather than production of hardware.

The Organization of Academic Research

Another problem that has required much attention is the management and organization of research, especially that kind of research which is carried on by large groups of investigators. The war demonstrated the effectiveness of research teams, and the Institute is now experimenting to determine how effective group research can be within an academic organization. In this experiment, we are certain that research teams should never displace the brilliant individualist who works alone, but we want to find out how the two approaches supplement each other.

One of the devices employed at M.I.T. to handle group research — and to stimulate individual work — is the "center of research" of which several are in operation. These are interdepartmental organizations which co-ordinate the co-operative activities of various departments in important fields of overlapping interest. While we call them centers of research because research is their predominant role, they are nevertheless playing a very important part in our educational program, especially by providing superior opportunities for senior and graduate student thesis work.

These centers of research appear to be a highly satisfactory answer to a problem which has long confronted educational institutions, namely, that of handling those interests which reach outside the traditional departmental boundary lines and require the co-operation of the specialists from several disciplines. Certain institutions have tried to meet this problem by setting up special institutes. Others have set up new departments. It is the feeling at M.I.T. that both of these solutions seem to be lacking in two desiderata: namely, the mobilizing of the interested personnel of the various departments into a co-operative whole while still recognizing each department's special interest in the various aspects of the program, and, most importantly, the full co-ordination of the research with the educational program.

Centers of research have been established in about half a dozen fields, but the first and the most highly developed of such programs is in the Research Laboratory of Electronics, which is operated jointly by the Department of Physics and the Department of Electrical Engineering. Some 65 graduate students are now doing their theses in this laboratory. It has a highly productive program of research that is managed by professors from the two collaborating departments and it maintains a concentration of equipment which is available to the staffs of the two departments.

We believe that this laboratory is serving as a pilot plant for a new type of internal collaboration among departments having the fundamental scientific point of view and departments having the applied point of view. Through such mechanisms as this we hope to effect a fruitful cross-fertilization and thus minimize the dif-

ferences which distinguish the engineer and the scientist. Joint laboratories of this kind also provide a means whereby the educational staff can cope with large-scale sponsored research. These laboratories provide a staff of administrative officers and services which free the educational staff from routine work, thus permitting them to concentrate on their educational and research activities.

Contract Research — Its Values and Limitations

Coming now to some of the special problems of sponsored, or contract, research, there are several guiding principles which have been laid down at M.I.T. and this article describes some inherent difficulties.

The first of these guiding principles is that the primary purposes of an educational institution are to educate men and women and to increase knowledge, not to compete with industry in industrial research or production for profit or to undertake activities which are the special responsibility of governmental agencies. Two factors may justify a secondary activity in the realms of these industrial or governmental interests: One is the importance of case material in any effective professional education. The other is the responsibility of an educational institution to render public service when it can do so without impairing its primary functions and when its personnel, facilities, or experience especially qualifies it to perform a needed service which cannot be performed adequately or in time by some other agency.

Our second guiding principle is that sponsored research should be closely related to the normal program and recognized objectives of the institution. It should involve only work which can be carried out with enthusiasm by the staff and it specifically should not be work which the staff would undertake with reluctance and which would be unrelated to their educational and professional programs. A member of the Institute's staff is never "assigned" to contract research.

The third guiding principle is that imposition of restrictions on publication of research results, either for secrecy or patent reasons, can become incompatible with the basic concept of an educational institution as a source and distributor of knowledge. Research contracts involving such restrictions, especially long-term or permanent restrictions, should be undertaken only for exceptional or emergency reasons. No arrangement is permitted which could inhibit free and effective work by the institution in any scholarly field. No project is normally accepted unless it is open to qualified students.

Our fourth guiding principle is that the compensation and privileges available to the academic staff, including graduate students who are members of the staff, must never suffer in comparison with the emoluments available to staff engaged solely for contract research. This policy is of the greatest importance, since funds available for contract research frequently are less restricted than funds available for the regular academic program, and there is a consequent temptation to pay higher salaries to the personnel working on these projects.

The Institute has carried out this policy of protecting the academic staff by distinguishing sharply between the academic staff, with its educational function, and the nonacademic staff employed specifically for contract research. The academic staff has important privileges, such as tenure, membership in the pension association, opportunity for graduate study, time for outside consulting, and extended vacations. None of these privileges is available to the nonacademic staff.

The compensation for nonacademic staff, however, is usually somewhat higher than are salaries of comparable academic appointees. In securing staff for research projects, we have had to meet industrial competition in recruiting, and their status with us is quite comparable to what it would be in industry.

The same general policy applies to graduate students who have part-time staff positions. The nonacademic staff member who wants to take graduate work is limited to one subject per term and he may not present a thesis based upon sponsored research work for which he has received compensation at a higher rate than that available to the academic appointee. In contrast, the regular graduate student who also has an academic appointment as teaching fellow or research assistant receives a lower rate of pay but has full graduate student privileges, including the opportunity to work on sponsored research and use this work for thesis credit, provided of course it has been approved and properly supervised.

Maintenance of these two rates of compensation requires some dexterous tightrope walking, but we have demonstrated, at least to our own satisfaction, that it can be done. In practice, the Division of Industrial Coöperation, which manages the Institute's sponsored research, gives preference to the academic staff when it is recruiting personnel for a contract project, but if the project cannot be staffed from our academic group, appointments from outside the Institute are made in accordance with the policy outlined above. Even though the salary scale may be somewhat lower for the academic staff, the academic appointment with the privileges it carries remains a more desirable appointment.

Related to this general policy is our limitation on supplementary compensation to academic staff members who work on contract research. Here we follow the policy that teaching and other normal academic duties must not be made less attractive than working on contract research. We share fully in the following recommendations of the Committee on Academic Tenure, Professional Service and Responsibility of the Engineering College Administrative Council:

"If equity demands that supplementary compensation should be paid for extra work within an institution, the amount of such additional compensation should not be so high that it tends to reduce the importance of the staff member's regular work and salary, and to place a value on contract research or nonacademic assignment that is high in relation to the value placed on the usual academic duties.

"Care must likewise be exercised to avoid compensation inequities within an institution which result when some staff members, whose field of work may attract outside research, receive large supplementary salary payments while other staff members, in fields of less immediate application, but possessing equal or greater scholarship and professional standing, receive from the institution only their regular salaries. No plan of supplementary compensation should put teaching in an inferior position or tend to divert staff members from their obligations to their students."

In practice, staff members working on sponsored research have enough time released (*Concluded on page 60*)

Oxygen for Industry

New Processes Making Possible Large Production, High Purity, Low Cost, Pave Way for Increased Industrial Uses for Oxygen

By Earl P. Stevenson

OXYGEN is not only the most abundant and the most vital of all elements, but historically its identification and simple reactions mark the birth of modern chemistry. The industrial separation of pure oxygen from the air in the early years of the Twentieth Century was a milestone in chemical engineering and provided a most valuable tool for the metal-working industries. World War II witnessed a renaissance in the study of methods of producing oxygen which promises to broaden its use in customary applications by reducing the cost of oxygen and, perhaps even more important, to permit for the first time its large-scale use as a valuable processing chemical.

The need for developing methods of oxygen production specifically suited for the needs of war became apparent during the defense period. On the day of Pearl Harbor an *ad hoc* reviewing committee of the Office of Scientific Research and Development, appointed by Dr. Vannevar Bush, '16, was formulating its final recommendations for a greatly expanded program of developing specialized methods of oxygen generation. The uses envisioned for this oxygen included: (1) submarine propulsion; (2) breathing of airplane crews at high altitude; (3) airplane "bursts of power"; (4) emergency welding and cutting on shipboard; (5) submarine air conditioning; (6) various medical uses in the field; (7) repair and maintenance of equipment in the field; and (8) secondary fuel for rocket propulsion.

Diverse though these needs were, they had in common the requirement that the oxygen-generating equipment be lighter in weight and simpler in operation than the plants then used industrially. In the course of the development program, these requirements were met. The wartime advances have consisted in modifications of the classical method of producing oxygen, which involves liquefying air and then separating its oxygen by distillation. The specific new developments [1, 2, 3, 4, 5] have already been adequately described from a technical point of view and will be only mentioned here. In brief, they include the low-pressure cycle, based on use of reversing heat exchangers, and improvements in the efficiency of expansion engines.

The reversing heat exchanger consists essentially of three concentric tubes. Through the center tube the outgoing pure gaseous oxygen flows continuously. Through the two annular channels compressed air and waste nitrogen (at atmospheric pressure) flow alternately. An important feature of the reversing heat exchanger is that, in addition to cooling the incoming air, it purifies the air by freezing out the air's minor condensable fractions, chiefly water and carbon dioxide, along with traces of hydrocarbons derived from lubricants used in the system. These impurities are deposited, as the air cools, on the walls of the channel through which the air flows. After a few minutes of such deposition, the air is switched to another channel and large volumes of nitrogen are sent through the first channel, where the nitrogen evaporates the impurities and carries them out to the atmosphere, thus preventing plugging of the channel with impurities. The conventional method of purification has been by chemical means, in separate equipment.

The effectiveness of the reversing heat exchanger in transferring heat from the incoming compressed air to the cold outgoing oxygen and nitrogen, in combination with other advances, is such that the air can be liquefied after compression to only about 75 to 100 pounds per square inch. The possibility of operating at this low pressure greatly simplifies operation and permits the use of less costly equipment.

To achieve its liquefaction, cold compressed air may be expanded either through a valve or through an engine, by means of which the expanding gas can do work on some mechanism outside the liquefier. Both methods have been used. In the course of the oxygen program, sponsored by the Office of Scientific Research and Development, design features were developed which permitted efficiencies as high as 85 per cent for small reciprocating engines and similar improvements were made in turbo-expanders, adaptable to large liquefiers. The efficiency of the expansion engine largely determines the cost of refrigeration and is particularly significant when dealing with large-tonnage industrial uses of oxygen, where cost is the first consideration.

Established Industrial Uses of Oxygen

During World War II there was, according to United States census reports, an increase approaching threefold in the industrial use of oxygen; from 4,500,000,000 cubic feet in 1939 to 11,000,000,000 cubic feet in 1946. These figures are for high purity oxygen — 99.5 per cent. In 1946 production was distributed among 228 plants operating in 37 states. According to recently published estimates [4] by The Linde Air Products Company the use of oxygen at the present time is distributed in accordance with the data given in the table on the following page.

[1] Lobo, W. E., and Skaperdas, G. T., "Air Purification in the Reversing Exchanger," *Chemical Engineering Progress*, February, 1947.

[2] Rushton, J. Henry, and Stevenson, Earl P., "Developments in Oxygen Production," *Chemical Engineering Progress*, February, 1947.

[3] Swearingen, Judson S., "Turbo-Expanders," *Chemical Engineering Progress*, February, 1947.

[4] "Oxygen — Past, Present and Prospects," *Chemical Engineering*, January, 1947, pp. 123–131.

[5] Collins, S. C., "Reversing Exchangers Purify Air for Oxygen Manufacture," *Chemical Engineering*, December, 1946, pp. 106–107.

Transportation of oxygen from point of production to point of use has always been a serious problem of the industry, and undoubtedly a deterrent to wider application. In the early 1930's shipment was entirely in standard steel cylinders of two sizes holding respectively 110 and 220 cubic feet of gas at 2,000 pounds pressure. Thus, two-way shipment of more than seven pounds of container was necessary for every pound of gas transported in one direction. With increasing use of large quantities by individual users, as in the steel industry, two other methods of transportation came into use in the late 1930's. One method employed 30,000-pound truck trailers carrying multiple high-pressure vessels, holding about 3,000 pounds of gas. The other involved shipment of liquid oxygen at substantially atmospheric pressure. Special insulated tank cars carry 62,000 pounds of liquid, equivalent to 750,000 cubic feet of gas at normal temperatures and pressures. Gas loss through evaporation and venting during shipment is surprisingly small. The liquid is vaporized in autoclaves at the consuming point to deliver gas to high-pressure storage at 2,000 pounds per square inch. In some cases oxygen-producing plants have been built adjacent to those of large consumers, and delivery is by pipe line. It follows that the cost of oxygen to the customer will vary widely. According to recent survey data this variation is between $3.00 to $20.00 per 1,000 cubic feet, or $65.00 to $450.00 per ton.

In the future, some consumers using oxygen for purposes now well established may side-step the transportation problem by operating their own small oxygen plants, producing between 1,000 and 2,000 cubic feet of oxygen per hour. A low-pressure cycle employing reversing exchangers possesses a number of advantages for small-scale operation. For example, the units can be made largely automatic, requiring no attention from operators except during periods of starting up, shutting down, and maintenance. These units can be made quite flexible in meeting the fluctuations in demand for oxygen in metal-working shops. They are also considered less hazardous.

Republic Steel Corporation

Slab scarfing: a typical industrial operation which may be expected to benefit from new processes of producing low-cost oxygen for industrial uses.

Present Uses for Oxygen

	Subtotal Per cent	*Total Per cent*
STEEL INDUSTRY		40
MACHINE SCARFING	6.5	
HAND SCARFING	23.0	
OTHER PRODUCTION	8.5	
MAINTENANCE	2.0	
STEEL FABRICATION		25
PLATE EDGE PREPARATION	7.5	
OTHER CUTTING	15.0	
WELDING	2.5	
INDUSTRIAL MAINTENANCE		8
MISCELLANEOUS USES		27
SCRAP IRON PRODUCTION	6.0	
CHEMICALS AND PETROLEUM	5.0	
AUTOMOTIVE AND AIRCRAFT	4.0	
MEDICAL AND BREATHING OXYGEN	3.0	
OTHER INDUSTRIES	9.0	
ALL USES		100

Consumer-operated plants can be expected to compete increasingly with companies long established for the distribution of oxygen, although the long-term results will probably be evolutionary rather than revolutionary in character. With increasing labor costs and advances in the art of using oxygen for multitudinous metal-working operations, it seems more than probable that the market now well served by the extensive distributing facilities of the established industry will not be too adversely affected for a long time. The extent of competition from relatively small captive or consumer-operated plants will depend in large measure upon the ability of the engineer to design plants that are largely automatic in operation and flexible in production, and which involve no maintenance problems beyond the skills ordinarily found in manufacturing plants.

Contrary to statements that have appeared recently in the technical and popular press, the quality of oxygen is not the issue in choosing between purchased and consumer-produced oxygen. It is true that low-pressure plants of the type used in Germany cannot produce oxygen of the highest purity, but this is not true of the type developed in this country during the war. There is, incidentally, a question as to whether many of the uses now served by the high-quality product could not use oxygen of lower quality — down at least to 98.5 per cent.

This may prove to be a rather important question in the case of consumer-operated plants, as there is a substantial increase in production capacity in low-pressure units with decreasing quality. In the case of one such unit, the capacity was increased by 25 per cent on dropping from 99.6 to 98.7 per cent.[6]

Prospective Tonnage Uses for Oxygen

With World War II came the necessity of meeting some unique problems and calling upon the participation of individuals and companies who had no previous association with oxygen production. The result has been some new ideas and the education of a number of engineers in this specialized field. General engineering concerns that service the process industries are now in position to design and construct large industrial units. This new familiarity with oxygen production, combined with the wartime technical advances, has brought closer to reality many tonnage uses of oxygen which were only speculations in the prewar era. Although these proposed new uses will draw on the same technical advances as will small consumer-operated plants, the industrial repercussions will be quite different, for, with only isolated exceptions, oxygen has never before been used on the scale and for the purposes now considered.

In recent months oxygen has been much in the news. A good deal has been written, some quite speculatively, about certain new large-tonnage uses for oxygen which are now just beginning to emerge from the experimental or development stage. These include: (1) the use of oxygen to produce carbon monoxide-hydrogen mixtures from either natural gas or coal for use in the synthesis of hydrocarbons and oxygenated chemicals; (2) the use of oxygen in the open hearth to speed up the melting of scrap and reduce the over-all time of the melt, with increased production; (3) the use of oxygen for enriching air used in the iron blast furnace; and (4) the uses of oxygen in gas-generating systems.

Manufacture of Synthetic Gasoline

The manufacture of synthetic gasoline is rapidly nearing commercial application in this country. The method derived from the German Fischer-Tropsch process and variously designated as the Synthol process, the Synthine process, and the Hydrocol process, has been described extensively in recent periodicals.[7] Synthetic gasoline produced by this process did not play a large part in the German oil technology during World War II. As engineered by the Germans, the unit costs were high and the products inferior to the gasolines available from hydrogenation of coal, on which Germany largely relied for its high-octane gasoline. Research and development work on this type of process in this country since 1938 has resulted in tremendous improvements in technology, greatly increasing the efficiency, reducing investment costs over German commercial applications, improving the quality of the hydrocarbon products, and producing substantial volumes of a large variety of oxygenated chemicals. An engineering feature introduced in this country is the application of the so-called fluidized technique, wherein a bed of finely divided solid catalyst is maintained in a turbulent state. The two plants now projected in this country, which are at the engineering stage, will employ oxygen rather than steam for converting methane, under conditions of partial combustion, to a gas having the desired percentage composition of carbon monoxide and hydrogen according to the equation: $8CH_4 + 4O_2 \rightarrow 8CO + 16H_2$.

Steel Making: Use in Open Hearth

By the use of oxygen in the flame during the charging and the melting-down period of the heat, or by introducing oxygen into the molten metal after melting in order to reduce the carbon content, certain economies have been realized. Large-scale tests have been carried out by several of the large steel companies during recent months with reported savings in time per melt of as much as four hours when handling a charge approximating 400,000 pounds. The amount of oxygen used per ton of steel so produced varies widely according to the conditions of use and may be as much as 600 cubic feet per ton. For a steel plant operating 10 open hearths and having a daily producing capacity of 6,000 tons this would represent an over-all daily demand for oxygen of 3,600,000 cubic feet, equivalent to 160 tons of oxygen. Some estimate that the open-hearth furnace capacity may be increased 40 to 60 per cent by this means. In terms of the cost of oxygen the break-even point will vary widely from plant to plant and change rapidly with market fluctuation and other conditions, but some have concluded that a worth-while saving would be realized if oxygen could be produced at about $10.00 per ton; others estimate that, to be attractive in terms of the large investment required, the oxygen should be produced for not more than $5.00 per ton. In all of these large-scale projected tonnage uses for oxygen the price at which it can be produced is the determining factor. Industry-wide adoption of the use of oxygen in open-hearth practice would mean an investment in the near future of up to $200,000,000.

Use in Blast Furnace

The iron blast furnace can be rated as one of the most important units in our industrial economy. With more than 200 units and producing capacity of 66,000,000 tons per annum, the United States today has in excess of 50 per cent of the pig iron producing capacity of the world. With the present position of the scrap market, pig iron is in demand beyond the maximum which can be produced today, and new blast furnaces are being planned. From the chemical point of view the factor limiting production is the amount of oxygen that can be blown and converted into carbon monoxide at the tuyères. The amount of air that can be blown into a furnace per minute has been limited largely by mechanical considerations, such as the increasing entrainment of fine ore particles in the blast-furnace gas with higher rates of blowing. With the industry increasingly dependent upon finer grain ores and forced to use inferior grades of metallurgical coke, the trend is toward a reduction in the producing capacity per furnace. Several suggestions are being advanced for correcting this situation. One of these is beneficiation of ore through flotation to increase the percentage of iron content, and sintering to increase the average grain size. A second proposal is to increase the

[6] Lobo, W. E., "Oxygen by Fractionation at Low Pressures," *Chemical Industries*, July, 1946.

[7] Roberts, George Jr., and Phinney, J. A., "Manufacture of Synthetic Gasoline Nearing Commercial Application in U. S.," *Oil and Gas Journal*, March 15, 1947.

average gas pressure within the shaft of the furnace by increasing the blowing pressure and throttling the discharge gases with increase of top pressures to possibly 20 pounds. Two furnaces have been operating on this principle for some months and have demonstrated the feasibility of substantially increasing the rate of blowing under these conditions, with corresponding increase in production. The third means suggested for increasing production is that of enriching the blast in oxygen. At present the benefits must be calculated from the rather inadequate data of a few tests on European furnaces in 1940 and 1941. Large-scale tests now planned for at least one furnace in this country should decide this controversial issue. With enrichment to 30 per cent. It is predicted that fuel requirements will be cut 8 per cent and production increased about 20 per cent. To break even, oxygen should cost slightly less than $5.00 a ton, according to estimates of some operators. For enrichment to 30 per cent, a furnace normally blowing 75,000 cubic feet of air per minute would require 12,000,000 cubic feet of oxygen per day.

When this possibility is considered in combination with the rather certain large-scale use of oxygen in open-hearth practice and present substantial demands for oxygen in a steel plant, it is predicted that large oxygen generating plants will shortly be as indispensable and essential for the most efficient over-all operation of a steel plant as are the present utility facilities, coke ovens, fuel gas generators, and power plants. Through such installations will come greater flexibility in adjusting the various operations which enter into the manufacture of steel to meet changing economic conditions within the industry.

Gasification of Coal

The equivalent of some 170,000,000 tons of coal annually is consumed in the form of gas by industrial and domestic users in the United States. Of this total, gas made from coal accounts for the equivalent of some 21,000,000 tons, and the rest is mostly natural gas transported over long distances in pipe lines.

In this country, gas is made from coal chiefly by three processes, which give rise to coke-oven gas, carbureted water gas, and producer gas. Coke-oven gas results from the heating of coal in coke ovens in the manufacture of coke and is thus essentially a by-product. Cheap oxygen promises to play an important role in the latter two processes. In the traditional water-gas process steam is made to react with incandescent carbon in an operation in which a mass of coke or coal is alternately blown with air, to heat it by the combustion of a portion of coke or coal, and then with steam, to effect gasification of another portion. Blue water gas results and is a mixture of hydrogen and carbon monoxide, with a heating value of nearly 300 British thermal units per cubic foot. This gas is enriched to "city gas" heating-value standards (usually more than 500 British thermal units per cubic foot) by having petroleum oils cracked into it in the carburetor portion of the water-gas set. Producer gas, largely for use in industry, is made by continuously blasting a deep hotbed of coal or coke with a mixture of air and steam. Obviously, the nitrogen introduced as air dilutes the product gas, which may have a heating value as high as 180 British thermal units per cubic foot when made from high volatile coal, and as low as 110 British thermal units per cubic foot when made from low volatile coke in poor operations.

Republic Steel Corporation

Charging hot metal in open-hearth furnace. The steel industry will undoubtedly be one of the largest users of oxygen for industrial purposes.

The complete gasification of coal with resultant high heating-value gas in a continuous process has long been held up as a potential goal in the manufacture of gas from coal. Operation of a process based on the producer-type reactions with steam and oxygen, instead of steam and air, could result in the continuous complete gasification of the coal without the diluent nitrogen being present in the gas. Gasification may be combined with a second step wherein a portion of the hydrogen-carbon monoxide is reacted to form methane, having three times the volumetric heating value. After removal of any carbon dioxide the product of this combination process yields a gas having a heating value up to about that of methane, or about 1,000 British thermal units per cubic foot.

Such a combination of steps may become the means by which coal can be gasified at the mines and the gas transported via pipe line to consuming points, much as natural gas is now transported. This has been visualized with reference to coal mines in West Virginia, Pennsylvania, and Illinois, with distribution of gas to the major industrial regions of northern and eastern United States.

Based on Braunkohle, lower in quality than any coal of commercial significance mined in the United States, and oxygen produced in Linde-Fränkl liquid air plants, the German Lurgi development effects this combination of steps to get a gas of some 500 British thermal units per cubic foot in a continuous process at an efficiency equal to or surpassing that of the producer-gas process.

American chemical engineering talent is now being applied to process design problems, in the solution of which the Germans showed poor aptitude, in order to bring this method of coal (*Continued on page 62*)

Colloids in Science and Industry

From Rubber Tires to Whipping Cream, Surface Phenomenon Plays a Predominant Role in Creating the Products of Modern Colloidal Chemistry

By Ernst A. Hauser

DURING the last few years colloid chemistry has made many outstanding contributions to science and industry. As a firm basis for future recognition its wartime contributions may be offered, inasmuch as this branch of science was, in fact, an important cog in making possible many of the most important military operations of World War II. Of course, it would not be proper to say that the war was won simply and alone by colloid chemistry. But when our armies landed on the beaches of Normandy, or crossed the Rhine; when our bomber squadrons blasted important military objectives, such as the Krupp armament factories, or the plants of the large German chemical companies in Leverkusen or Ludwigshafen; when Hiroshima and Nagasaki were devastated by the atomic bomb — the colloid chemists are included in the not too large audience who realize that all such operations would have been impossible without knowledge of the colloid chemistry of rubber.

Rubber was needed for the inflatable boats which were used to put our men ashore and the pontoons with which they built emergency bridges. Heavy cannons and tanks would have been useless without rubber caterpillar treads, and, without tires, no bomber could have left the ground. In the final analysis, our entire synthetic rubber industry is based on knowledge of the colloid chemistry of the milk, or latex, which exudes from the natural rubber tree growing in the Far East and in the jungles along the Amazon River and its tributaries.

But it is not only in the important field of rubber that colloidal chemistry plays a major role. The entire petroleum industry leans heavily on colloidal chemistry for the many products and by-products derived from petroleum. Indirectly, the American housewife comes into daily contact with the products and results of colloidal chemistry when she uses synthetic plastics, soaps, gelatins, jellies, and even whipping cream.

In spite of its vast and widespread importance, colloid chemistry is a field which, to date, has not achieved the recognition it deserves. The neglect of this science could be illustrated by citing the devastating floods which have occurred in the Middle West this year, and the fact that Congress is debating the need of allotting a large sum of money to be used in the construction of dams to avoid a recurrence of such a disaster. Yet soil stabilization is no longer a problem for colloid chemists who would be able to make valuable contributions to soil conservation if their advice were sought. Possibly, the neglect of this branch of science lies not alone with industry or government, but, in part, with our educational institutions, for the teaching of colloid chemistry is limited to a few colleges, of which M.I.T. is one. Still, industry, educational institutions, and government research alike have a share in the present status of colloid chemistry, for as has already been pointed out,* it is no longer possible to neglect this branch of science without inhibiting general progress in science and technology.

All on the Surface

Colloid chemistry should not be considered solely as another branch of chemistry, such as inorganic or organic. As physicochemistry applies to both, so does the science of colloids. Colloid chemistry is actually the chemistry of matter present in such a degree of subdivision that its surface is the predominant factor. It is this surface development, and the lack of chemical saturation of the atoms or ions located therein, as compared to those located below the surface, which account for the reactivity of colloidal systems. To explain in somewhat more detail what is meant, let us consider the following reaction:

$$KBr + AgNO_3 \rightarrow AgBr + KNO_3$$

Reduced to words this symbolic notation states merely that potassium bromide plus silver nitrate yields silver

* The Technology Review, February, 1941, p. 158.

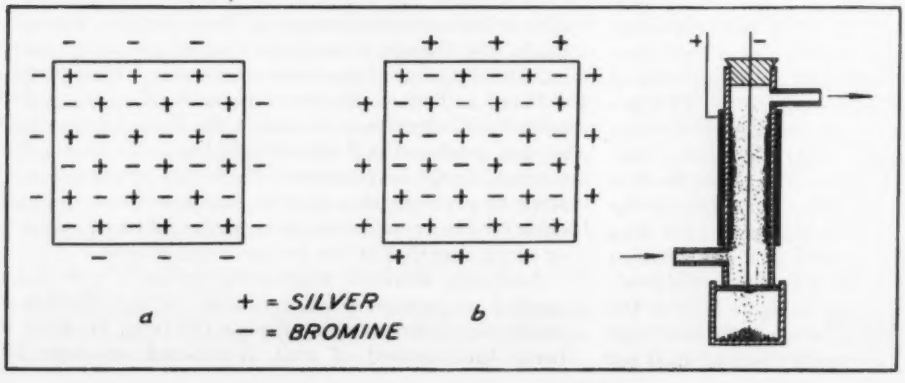


Fig. 1. (left) When potassium bromide and silver nitrate react, newly formed silver bromide particles have negative surface charge if there is excess of potassium bromide as shown at (a); positive charge with excess silver nitrate, as in (b).

Fig. 2. (right) Schematic diagram of Lodge-Cottrell precipitator which makes use of removal of smoke by electrically separating charged colloidal particles.

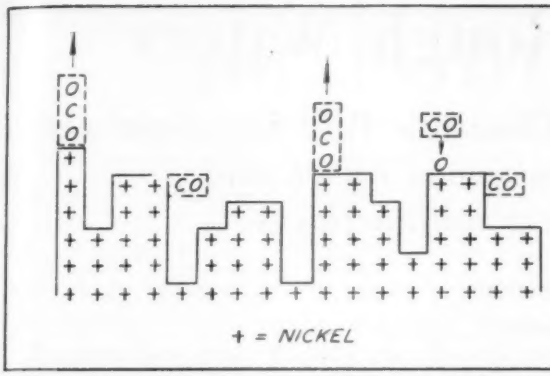


Fig. 3. Surface charge is the basis for the formation of carbon dioxide when oxygen, carbon monoxide, and colloidal nickel are brought together at elevated temperatures.

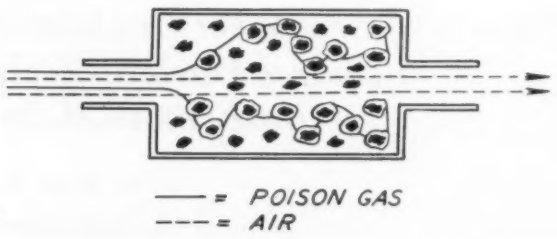


Fig. 4. The effectiveness of gas masks depends upon the removal of poisonous gas particles by combining them with colloidal carbon through the surface charges of these two substances.

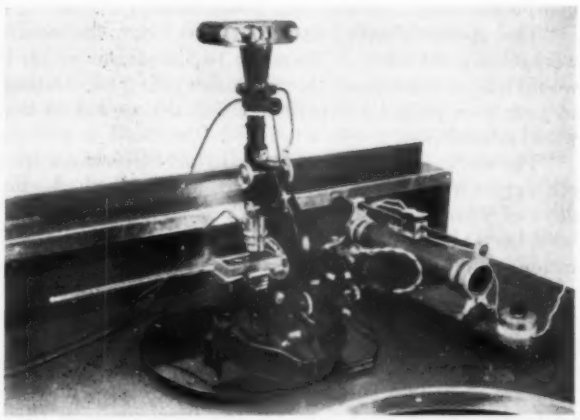


Fig. 5. Direct visual or photographic study of the effects of time and temperature on elastic substances can be studied with new techniques in which incident light is applied to the ultramicroscope whose substage can be heated.

bromide plus potassium nitrate. This reaction — the double exchange of metals and radicals as expressed symbolically above — is all that is of importance to chemists who customarily deal with atom aggregates large enough so that surface phenomena are submerged by the effects of mass action.

The colloid chemist is not yet satisfied with the state of affairs so simply stated by the chemical equation. He notes that the silver bromide crystals which are found in this reaction have surfaces composed of silver and bromine ions which are not saturated; that is, they are lacking ions of opposite charge as compared to those located below the surface. If the reaction is carried out with an excess of potassium bromide, then the silver ions on the surface of the newly formed silver bromide particles will react with some of the excess bromine ions and a particle carrying a net negative surface charge results. The excess potassium did not react with the bromine of the crystals because nature always tends to have a reaction form the least soluble compound. If, however, silver nitrate had been in excess, the particles would have acquired a positive charge due to the preferential (*Continued on page 66*)

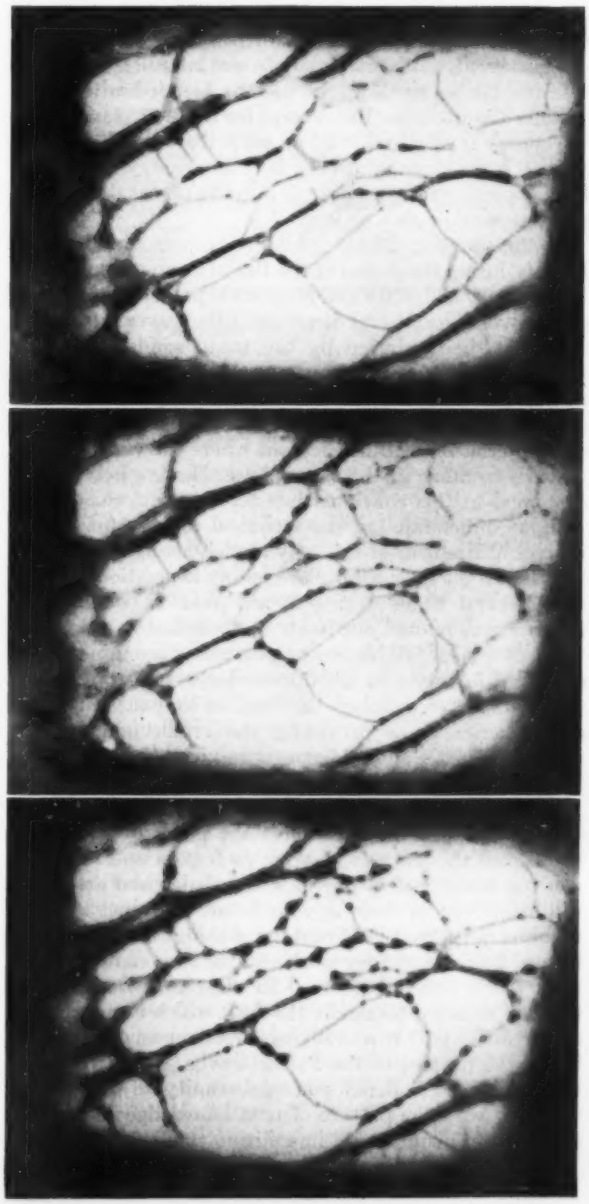


Fig. 6. A series of photomicrographs of a sample of Cryptostegia grandiflora rubber showing structure upon formation (top) *and the changes which occur after 15 hours* (center) *and again after 30 hours* (bottom).

Safely through Rough Waters

Members of September Graduating Class Are Told Successful Life Requires Patriotic Zeal, Sustained Effort, and Willingness to Make Personal Sacrifices

By Karl T. Compton

Valedictory Address *

OFTEN I have thought of the many analogies which can be based upon the waves on the ocean. These waves carry for a long time and to distant places the energy imparted to them by some event like a storm or a suboceanic earthquake. They carry the record of the original event, first very definitely and later in a more diffuse fashion as these waves become blended with other oceanic disturbances. But, except for the slow dissipation, the energy is carried on and on until the wave ultimately dies on some shore, and even here the energy is not lost but is transformed into heat or into the physical displacement of sand or rock or ice.

In the summer of 1946, while flying over the Marshall Islands during the period of the Bikini atomic bomb tests, I saw a very elaborate and large-scale pattern of interference waves. The general direction of the waves is from the northeast, being driven by the trade winds, but from every coral island the waves are reflected so that the entire surface of the ocean is crisscrossed by an elaborate pattern of interference waves with hyperbolic lines of calm alternating with the regions where the various wave systems combine in the same phase. Having become accustomed to this continual interference pattern, though without understanding the technical reasons for it, the natives utilize it most skillfully as they navigate between the islands on their fishing or trading expeditions. There were several times during World War II when these natives thus piloted our boats to their destinations.

In some such fashion, by analogy, we may think of the events of history and the discoveries which, throughout the years, have enriched the fund of human knowledge and experience, as providing the intellectual pattern whereby we can advantageously navigate our own lives if we have the intelligence and training to profit by them.

Just as the waves on the sea reconstitute the pattern of past oceanic events, so have the pages of your textbooks and the lectures of your professors opened up to you the storehouse of previous knowledge and art which will assist you in steering your future activities so as to take the best possible advantage of things that have gone before. Your laboratory work and the innumerable problems which you have solved in class exercises provide the skill required to handle the craft which is your future career. Just as my trip to Bikini offered me an opportunity to see the pattern of the Pacific waves, so has your trip through M.I.T. offered you opportunity to become acquainted with the pattern of past knowledge and experience and to acquire skill in utilizing this information.

* Delivered to the 439 members of the Class of 9-47, in Walker Memorial, September 26, 1947.

A few days ago in conversation with Governor Bradford of Massachusetts, he called my attention to a very interesting quotation from the writings of an Englishman, John Selden, in the year 1641. The quotation was:

"The storm is over, the wind lieth, but the ocean worketh a great while." There are two analogies which I would like to draw from this quotation: the first relating to your own personal experience; and the second to the world situation.

"The storm is over, the wind lieth, but the ocean worketh a great while." The storm may be likened to the hectic days of your career at M.I.T. These days have not all been hectic but this institution has a well-deserved reputation for hard work and there are periods of examinations and tests or other emergencies which are unusually strenuous. The unsettled conditions of our postwar readjustments have accentuated these various disturbances.

Now, "the wind lieth". The examinations are passed. You are no longer subject to the daily lectures of your professors (their wind lieth for the moment until they have to begin lecturing to the new classes). The winds and storms of life will again blow around you from time to time as you settle into your professional activities.

"But the ocean worketh a great while." By this I mean that the influences which have been created in and around you during the college course will, like the waves, continue to operate for a great while and in fact throughout your lives. As time goes on the particular influences of your educational experience will become blended with many other influences from the activities and environment in which you work, and the whole of these influences will constitute the ever growing pattern by which, with intelligent interpretation and skillful adaptation, you can steer your life's career.

Finally, at life's end, your individual pattern will break up in the sands of time but even then, as also throughout your life, the energy or influence of your lives is not lost but is rather transformed or continued in some other form.

Turning now to the second analogy which applies to world events, I can make the application suggested by Governor Bradford — "The storm is over, the wind lieth, but the ocean worketh a great while." The storm of World War II is past, the fighting has stopped, the tremendous pressure of war activities has dropped, but still "the ocean worketh a great while" because the economic and political disturbances created by the war are still with us and will be with us for many years to come. Just as during the war the great problem facing our civilization was to ride through the storm successfully, so also, now that the storm is over, the world is still faced (*Concluded on page 70*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

For Quality in Education

Analyzing Trends in Higher Education, President Compton's Annual Report Emphasizes the Institute's Needs for Postwar Leadership.

TRENDS of higher education in the United States and the responsibility which privately endowed institutions of higher learning must assume for developing leadership in students of superior ability are thoughtfully analyzed in the stimulating report which President Compton presented to the Corporation at its meeting on October 6. Coming at the beginning of a year in which M.I.T. is called upon to train the largest student body in its history, Dr. Compton's annual report provides an admirable survey of the need for quality in higher education, and records in considerable detail the Institute's current program for fulfilling its obligations to the nation as well as to its present portal-bulging student body.

In his discussion of the status and trends of higher education in the United States, Dr. Compton reported:

Most of us have been prone to think of the present overcrowded conditions in our institutions as due to the sudden release to college of the great group of young men whose education had been interrupted by military service, this trend to college being aided and abetted by the G. I. Bill of Rights. This is of course true. What is not generally realized, however, is that the present total college enrollment is really not very far out of line with what it would probably have been if the trends of enrollment during the years prior to 1940 had simply continued uninterruptedly through the war years to 1946. For several decades there has been a steady increase in the number of our young people going on for higher education. If it had not been interrupted by the war and if the prewar curve had been extrapolated through the war years, the total enrollment in institutions of higher learning would be just about what it is today. The difference is that this enrollment has come upon us suddenly after the discontinuity of the war, and our institutions have not been able to adjust themselves to it financially and in facilities and teaching staff so readily as if the growth had proceeded in its gradual, normal manner.

In the past academic year there were a little more than 2,250,000 students enrolled in our institutions of higher learning. This is nearly 60 per cent more than in 1939–1940 and is four times as many as were enrolled immediately after World War I in 1920. The Office of Education estimates that there will be at least 3,000,000 students in our institutions of higher learning by 1950 and that this number will continue at somewhat like this level until there is another big jump in the 1960's with the increased number of young people who were the war babies of World War II.

On the average, about one in every three high-school graduates now goes on to college. Spot surveys in several parts of the country indicate that less than half of the best of the high-school graduates go on to college and that the principal reason for this low proportion is lack of financial resources.

On the financial side there are some statistics which are quite significant. In the last normal year, 1939–1940, the colleges of the country spent an average of $350 per year per student. This is of course the cost of education and does not include the living costs of the students. The significant fact, however, is that the average annual amount spent by our colleges per student, reduced to terms of the purchasing power of the dollar, has steadily declined ever since 1930. This fact, combined with the progressively increasing demand for higher education, can mean only that our country has let the pressure for numbers and the competition of other demands upon our national income operate to an over-all decline in the quality of our higher educational program.

One reason for this is the pronounced decrease in private contributions toward higher education and the corresponding increase in support from public funds. In 1920–1921 private contributions amounted to $158 per student, whereas in 1941–1942 they were less than half this amount, namely, $73 per student. The tendency has been to take care of the demand

President Compton Reports

Dealing with problems of higher education in the United States, in his report to the Corporation on October 6, President Compton stated that:

People in the United States spend 20 times as much for amusements, cosmetics, jewelry, tobacco, and liquor as they do for education at university level.

Present college enrollment is probably what it would have been if the prewar trend had been permitted to continue uninterruptedly between 1940 and 1946.

The almost complete cessation of normal educational activities at university level during the war, followed by the sudden, abnormal increase in postwar enrollment are the primary factors responsible for the present difficulties which colleges face in their finances, in maintaining high standards, in building adequate faculties, and in expanding housing and educational facilities.

It is both proper and inevitable that the Federal Government should sponsor higher education to a greater extent than it did prior to World War II.

Since political tendency is toward equality of distribution, the obvious danger of Federal sponsorship is that the standards for higher education will be lowered to the level which the masses can assimilate.

The complementary factor which is required, therefore — and the task which privately endowed institutions must meet — is that of providing superior education for, and developing leadership of, superior students willing to work for and merit opportunities.

The continued strength of privately controlled institutions must be looked to for sustaining high standards in publicly supported institutions of learning.

The Year's Highlights at M.I.T.

The following highlights are extracted from the President's Report, given by Dr. Compton to members of the Corporation at their annual meeting on October 6.

New educational facilities added during the year include a field station for the Laboratory of Nuclear Science and Engineering, and a new Gas Turbine Laboratory which was dedicated on October 7.

The 5,600 students enrolled for the year 1947–1948 represent an increase of 80 per cent over the Institute's prewar stabilized enrollment, and a 10.8 per cent increase over the previous all-time high of last year.

The gift of $500,000 from the Alumni Association supplements funds earmarked for student housing and makes possible the construction of a new Senior House accommodating 360 students, begun October 6.

The Institute's nonstudent personnel exceeded 3,400 in 1947 as against 1,300 in 1940.

Total expenditures for the fiscal year 1946–1947 exceeded $17,000,000 or more than five times the largest prewar budget.

Now operating a $17,000,000 program with plant and endowment adequate for a $3,500,000 prewar program, the Institute has initiated a program for increasing its financial resources by about $21,000,000.

for college education more and more through the tax-supported institutions, and these of necessity have had to cater more to the mass than to the individual. Although only one-third of all the institutions of higher education in the United States are tax supported and under public control, these one-third enroll more than one-half of all the students.

The financial problem confronting the institutions of higher learning is easily understood from the combination of the following factors: (1) the decrease in private contributions, which undoubtedly is due to the higher income-tax rates; (2) the fact that income from invested endowments has decreased by at least a third; (3) the increase in over-all operating costs, including salaries, wages, and costs of material, which have approximately doubled. . . .

On the average over the country student fees took care of approximately 40 per cent of the cost of instruction in 1939–1940, but at the present time this average has risen to 56 per cent. In other words, the colleges, faced with the financial dilemma, have been forced to meet at least part of their financial problem by increases in tuition. In one way I believe that this is generally justified because the average per capita earning power of the American people has approximately doubled in this same period. It is reasonable to expect, therefore, that the average family could take care of twice as much cost of education as it could have in 1939–1940. . . .

. . . *Education: Quantity and Quality* . . .

There seem to me to be two major objectives which tend to dominate the direction in which our higher education is moving. Both of these objectives are good and they should be complementary. There is a danger, however, that they may become harmfully competitive. . . .

The steadily increasing demand by the public for higher education, combined with the shortage of any other funds for providing this education, has given increasing stimulus to the demand for larger public appropriations. The states are very spotty in their response to this demand. The trend has therefore been toward Federal funds for such support. . . .

A strong argument can be made for such Federal support on at least three grounds: In the first place, it would meet a public demand. In the second place, it is the only apparent way in which educational opportunities can be more or less equalized for students from various parts of the country. In the third place, the lessons of World War II have emphasized the importance to our national security of a population which is well educated, not only in the scientific and technical lines but also in the facts of history, economics, and social institutions. I believe, therefore, that it is both proper and inevitable that the Federal Government should step into the breach and sponsor higher education to a substantially greater extent than in the past. It remains to be seen whether such support will be made available on some appropriate basis to all qualified institutions of higher learning or only to existing and to new publicly controlled institutions, and also whether it will be accomplished by outright grants or by some form of contracts.

Both inevitable and proper in the thinking of Federal agencies is the attention to the masses of the population. The ideal will be to make higher education available to all who are qualified to benefit by it, irrespective of race, religion, or economic status. . . . The young manhood and womanhood of the country will be viewed as raw materials which should be properly developed as national assets.

Freely granting the logic and the benefits of such a program, there are some dangers inherent in it unless certain complementary moves are also made. The most obvious danger is that the entire program of higher education will be brought to a mass level which at the worst could be mediocre and at the best could be rather far from optimum. The complementary factor which is required is attention to a superior type of education, admittedly more expensive and selective than that which can be afforded for the masses, aimed primarily at providing the highest quality of educational advantage for students of superior potential and at the same time providing the best possible type of educational leadership for all higher education. It is possible, if Federal funds are wisely administered, to give proper emphasis to this quality factor as well as to the quantitative factor. This has been notably achieved already in the case of certain state institutions. Nevertheless, the political factors are against long-term emphasis on quality in state institutions because it is politically difficult to justify under governmental auspices a higher grade of opportunity for one person than for another. The political tendency is always toward equality of distribution.

Here, as I see it, is the great continuing challenge to the privately supported educational institutions. To some of them, at any rate, in every category of liberal arts or professional education, there is the responsibility of providing leadership, and of providing the opportunity for a type of education which is superior to that which can be provided for the masses and which should be made available to those qualified individuals who are able and willing to pay the price as an investment in their future. The existence of such institutions as Harvard, Chicago, M.I.T., and many others is, in the last analysis, the greatest safeguard of higher education against the dangers of political domination. I believe that the continued strength of these great privately controlled institutions will be responsible in no small measure for sustaining the excellent standards and high-minded administration of the majority of the publicly supported institutions.

Lest I be misunderstood, let me amplify the preceding paragraph. I do not argue for an undemocratic special privilege for a favored class. I do argue for freedom of the student to seek special educational opportunities and to profit by them if he is exceptionally qualified. For some students this will be easier than for others, thanks to financial resources which are incentives and rewards of our free enterprise system. But any young man can work, as I and my father before me and thousands of others have done, to earn these opportunities. And the most promising students can be helped by the scholarship and loan funds which so many socially minded people have generously provided for just this purpose.

Critical study of the origins of the basic new discoveries and

concepts which underlie so much of our modern civilization points almost startlingly to their origin in countries where highest educational opportunities have been largely concentrated on the most gifted, or most fortunate, among their youth. What we must try to achieve in America is a high level of mass education which will provide especial opportunity and all possible help for those who combine special gifts for creative scholarship with the earnest ambition to make whatever sacrifices may be necessary to achieve their goal.

To those, therefore, who believe sincerely in free enterprise, in the value of initiative to develop and operate institutions of superior quality, to those who wish to make available such opportunities to the most gifted of our youth, there is a great challenge. Since the most serious problem confronting all institutions is a financial one, the response to this challenge must also be measured in large part in financial terms. . . .

The total cost of all higher education in the United States is annually about half of one per cent of our national income, or a little over $800,000,000. For purposes of comparison, this amounts to about one and a half days' expenditure by our country in World War II; or about one-third the amount which is spent annually for operating our entire secondary-school system; or about one-half the estimated cost of operating universal military training for one year. Put another way, $800,000,000 is about five per cent of the amount which the American people spend each year for liquor, tobacco, jewelry, cosmetics, and amusements. The aggregate capital funds held by all institutions of higher learning in the United States are about one and three-quarter billion dollars, or about equal to the total assets of all the great altruistic foundations of the country.

These sums, while large, are small in comparison to the relative importance of the objective. If the importance of this objective is adequately realized by thoughtful people in the community, it should be easily possible, through private gifts from individuals, foundations, and corporations, to maintain our strategically located private institutions of higher learning in a condition to supply the leadership and the opportunity which are necessary to balance in a wholesome manner the increasing trend toward higher mass education. . . .

. . . *M.I.T. Year in Review* . . .

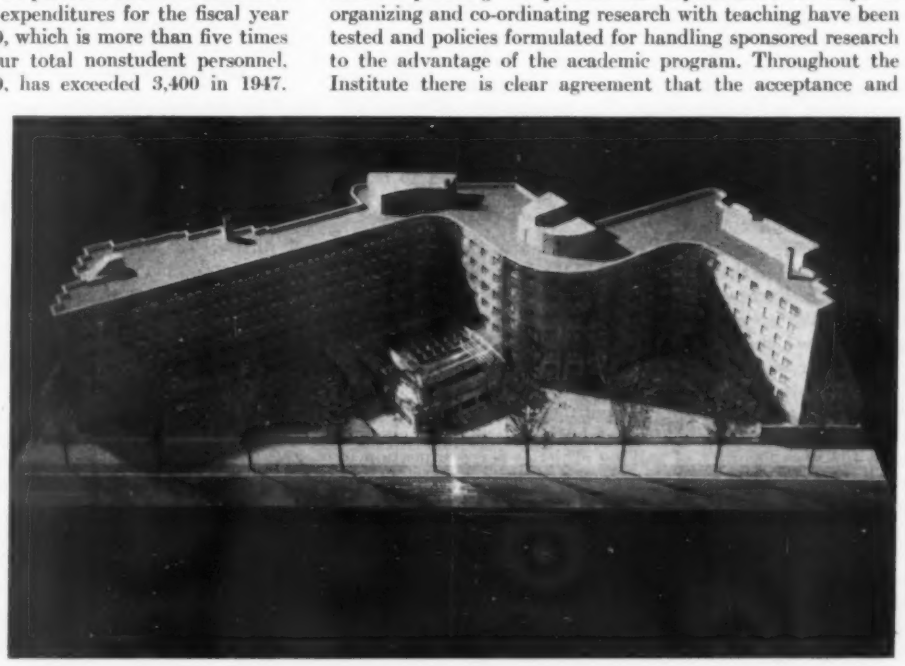
Our enrollment during the present term will probably reach 5,600 students, an increase of 80 per cent over our stabilized prewar registration. Our total expenditures for the fiscal year 1946–1947 exceeded $17,000,000, which is more than five times our largest pre-war budget. Our total nonstudent personnel, which numbered 1,300 in 1940, has exceeded 3,400 in 1947.

While we do not wish this present overload long to continue at its present level, I believe it fair to say that it has not yet held our figurative nose to the grindstone so completely as to prevent forward-looking activities along with the heavy routine. The past year, in fact, brought steady progress in the retesting and rethinking of the Institute's program and witnessed a mounting interest throughout the Institute in new ways of enriching our educational work. Creative research has flourished. There is some indication that publication of research results has lagged through lack of time to prepare manuscripts and through the persistence of the wartime habits of reticence.

. . . *Educational Survey* . . .

Last year, in my report, I spoke of the desirability of a strong faculty committee to review our educational policies and procedures. Such a committee has been appointed, together with a group of sub-committees, and has initiated a deeply probing study of those factors which make an educational institution vigorous in scholarship and in spirit. Not only is it reviewing our undergraduate curriculum in the light of our prewar objectives but it is reaching out to consider what the objectives of the future should be in the training of scientists, engineers, and architects. It is giving special attention to the problem of how to take the next step in creating a more effective partnership between the humanities and professional education and in specifying what kind of training will best equip an engineer to handle the great social responsibility and power which must inevitably rest in his hands. And, finally, it is tackling some of the imponderables mentioned above, which promote scholarship and which build citizenship. What, for example, are those factors which we must emphasize in the future to provide the best possible environment for scholarly, creative work by students and staff? This committee includes Professor Warren K. Lewis, '05, chairman, Professor John R. Loofbourow, secretary, and Professors Ronald H. Robnett, C. Richard Soderberg, '20, and Julius A. Stratton, '23.

Concurrently with the study by the Committee on Educational Survey, other approaches to the problem are being followed. The Committee on the Graduate School, under the leadership of Dean J. W. M. Bunker, has reaffirmed and protected our high standards of graduate study while at the same time it has provided greater flexibility and freedom to the individual student in pursuing his professional objectives. New ways of organizing and co-ordinating research with teaching have been tested and policies formulated for handling sponsored research to the advantage of the academic program. Throughout the Institute there is clear agreement that the acceptance and



SENIOR HOUSE

On October 6, President Compton broke ground along Memorial Drive for a new senior dormitory designed to house 360 students. Designed by the Finnish architect, Alvar Aalto, Senior House will afford a view of the Charles River and Boston from each room, as this model indicates.

A gift of $500,000 from Technology Alumni made possible the construction of this much needed unit at the present time. It is anticipated that the dormitory will be available for occupancy by next summer.

priority of any sponsored research program are governed by the extent to which the proposed activity will carry forward the educational objectives of the institution. The acceptance of this principle has been accompanied by the general recognition that our sponsored research programs can, if properly managed, help to create the environment most conducive to scholarship and creative activity.

During the year there has been a fresh and constructive concern with teaching methods throughout the Institute, and several departments have instituted programs for checking and improving the instructional techniques of young staff members. Reflecting the current interest of students in educational methods, one of the student honorary societies has undertaken careful evaluation of individual instructors in selected departments, with the wholehearted collaboration of the departments.

There has been a trend, continuing from before the war, toward deepening engineering education through the adoption of more of the analytical tools of pure science, through more graduate training in engineering, and through the use of research to attract men of imaginative minds. Similarly the science departments have been deepening their programs, and the push, which began in earnest in 1930, to build a great School of Science occupying a position of equal partnership with the School of Engineering, is well on the way to its objective.

During the year, two highly useful additions to our educational facilities were brought into use. One of these, which we acquired by purchase, includes an Army-built structure and 46 acres of land in Lexington, Mass., which will serve as a field station for our Laboratory for Nuclear Science and Engineering. The other is our fine new Gas Turbine Laboratory, which . . . gives us the most complete gas turbine laboratory to be found in any educational institution.

. . . *Broadening Technological Education* . . .

Concurrently with the study of the Committee on Educational Survey, immediate efforts are being made to strengthen our program. Everett Moore Baker, who was appointed dean of students on January 1, 1947, and Thomas P. Pitré, who became dean of freshmen at that time, are systematically encouraging extracurricular activities and student counseling as effective tools to build citizenship and to widen the outlook of students. They have also developed ways of integrating these extracurricular activities with our humanities studies. For example, we have engaged a new staff member who will not only have charge of our courses in music appreciation but will be consultant to the dean of students on our growing student musical activities. The students have responded with instant and hearty appreciation and collaboration. The registration officers in all the professional courses have stepped up their own effective contacts with students, and throughout the Institute, personnel have thrown themselves into the over-all movement to bring students and staff into a community of scholars having the broadest possible outlook.

Contributing importantly and by design to this community building has been the new Director of the Medical Department, Dr. Dana L. Farnsworth, the Institute's first full-time Medical Director. With a background of both psychiatry and internal medicine, he is an ideal successor to Dr. George W. Morse, who retired after 26 years of service. And to serve the general welfare of the students, in close relation to the Office of the Dean of Students and the Medical Department, a full-time Director of Athletics, Ivan J. Geiger, has been engaged and charged with the responsibility of making athletics serve education in the broadest sense. Toward this end he has al eady greatly stimulated intramural athletics.

. . . *Assistance to Students* . . .

A significant section of President Compton's annual message dealt with assistance available to students at Technology. Prominently mentioned was the vigorous and helpful participation of the Corporation Committee on Student Activity, headed by Donald F. Carpenter, '22, whose program of new developments affecting student life was recorded on pages 544 and 548 of the July, 1947, issue of The Review. The resolutions of the Committee on Student Activity, adopted by the Corporation at its meeting last June, inaugurated a program for extended dormitory, athletic, and recreational facilities for Technology students.

President Compton's report also recalled the $500,000 gift of the Alumni Association to be used toward the construction of a new Senior House, as already reported on page 537 of the July, 1947, Technology Review. Designed to house 360 students, Senior House construction was officially inaugurated on October 6 during ceremonies at which Dr. Everett M. Baker, Dean of Students, presided. Brief addresses were made by President Compton, representing the Administration, Donald F. Carpenter, '22, for the Corporation Committee on Student Activity, by Raymond H. Blanchard, '17, President of the Alumni Association and representing Technology Alumni, and by George K. Parmelee, '49, representing the student body as president of the Institute Committee. Also taking active part in the ground-breaking ceremonies were Professor Leicester F. Hamilton, '14, chairman of the Dormitory Board, Donal L. Botway, '50, chairman of the Student Dormitory Board, and Vice-president James R. Killian, Jr., '26.

. . . *New Era* . . .

In setting forth the Institute's future plans in fulfilling its objectives for providing outstanding higher education in science and engineering, President Compton reported:

The year also brought the opening of a sustained effort to increase the Institute's financial resources. The present capital needs of the Institute are estimated to be of the order of $20,800,000, and we are aggressively occupied at the present time in seeking funds, project by project, to finance these needs. Any effort of this sort must go through an initial phase devoted to informing potential donors fully about the needs of the institution, and we are at present in the middle of this problem of stating our case. The next phase will require more extensive organization involving both Corporation and Alumni.

The program has been set forth in a bulletin entitled "M.I.T. — A New Era" which has been distributed to alumni readers of The Review.

Significant progress toward the realization of the Institute's capital needs conclude Dr. Compton's report in the following words:

The George Westinghouse Educational Foundation has established a George Westinghouse Professorship in Mechanical Engineering, which will be publicly announced very shortly.

The very attractive plans for the Charles Hayden Memorial Library were found to require funds substantially beyond those available. The architects have restudied the problem and arrived at a new plan which, in its preliminary showing, seemed to all who saw it to be even better than the earlier design and probably capable of erection within our budget.

Construction is under way on the Navy-financed, M.I.T.-operated supersonic wind tunnel, located on the extreme western end of our property. This project, involving about $2,600,000, will make available to us a facility in this field unsurpassed by any other in the country.

Based upon a finding of need by the United States Office of Education that the facility is necessary to provide education and training to veterans, the Bureau of Community Facilities

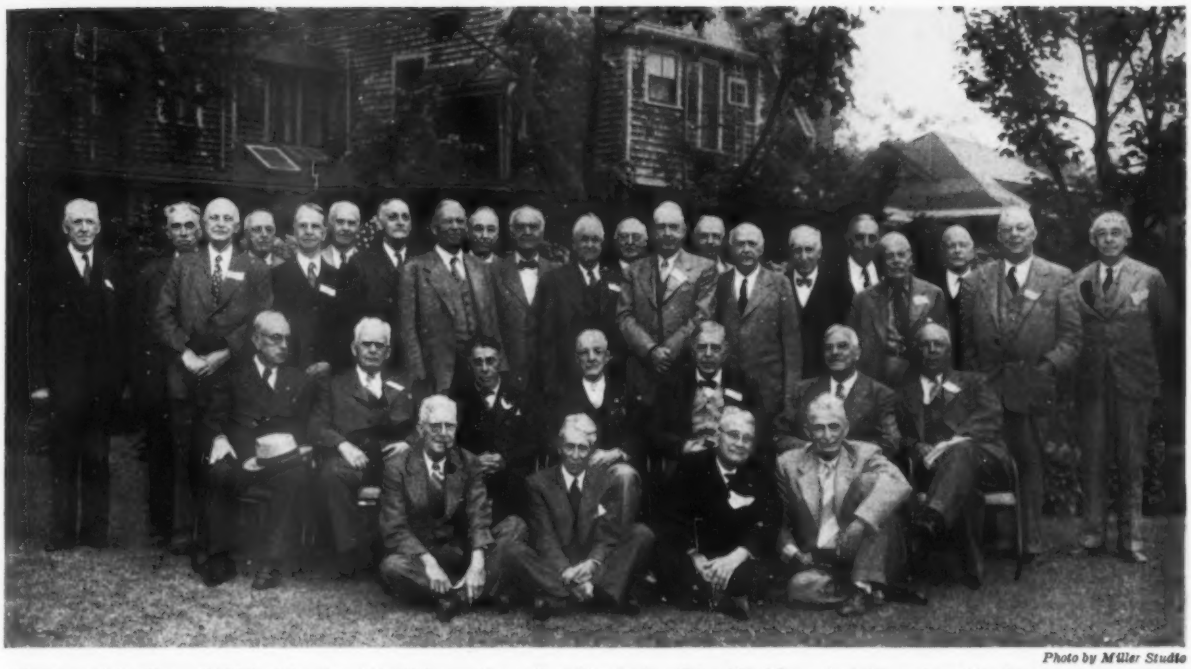


Photo by Müller Studio

Members of the Class of 1897 celebrating their 50th reunion at East Bay Lodge, Osterville, Mass., last June when this photograph was taken. In the first row, left to right, are: Chester D. Hubbard, Edward A. Sumner, Francis H. Shepard, Thomas R. Weymouth; in the second row, Edwin R. Olin, W. Charles Dunn, William D. Parker, John A. Collins, Jr., Henry E. Worcester, Stanley A. Hooker, Gilbert H. Pratt; and, in the last row, standing, Harry F. Sawtelle, Charles H. Eames, Frederick L. Edmands, George R. Wadleigh, Arthur S. De Wolf, Luzerne S. Cowles, Proctor L. Dougherty, Irenée du Pont, Royal H. Hayward, Augustus C. Lamb, Henry A. Clark, Dr. Albert P. Norris, Frederick A. Hunnewell, William Binley, John P. Ilsley, Charles R. Currier, Benjamin A. Howes, Wilfred Bancroft, Allen W. Jackson, Charles B. Breed, Henry W. Ballou.

of the Federal Works Agency is making available to the Institute a large drill shed located at Camp Peary, Va., which the Navy has declared surplus. This building will be transported to Cambridge, where 33,000 square feet of it will be used to construct an athletic building 200 by 165 feet; the remaining 17,000 square feet will be available to a government research project which needs hangar facilities at the Bedford Airport. Through the acquisition of this large structure, the Institute will be able by spring to have an athletic cage which essentially fulfills specifications which had been set up for this part of our ultimate athletic development.

A number of gifts or pledges have been received toward the Hydrodynamics Laboratory and Naval Towing Tank, but substantial funds remain to be secured before this laboratory can be constructed.

In support of our program in Nuclear Science and Engineering, which at present is being financed largely through the Office of Naval Research, one initial industrial contribution has been received and another large contribution has been pledged conditioned upon contributions from at least three similar corporations. Based upon negotiations to date, we feel exceedingly optimistic over the possibility of successfully arranging for this private support of our program during a period of several years.

Heads Mechanical Engineering

APPOINTMENT of Professor C. Richard Soderberg, '20, as head of the Department of Mechanical Engineering at the Institute was announced by Dr. Karl T. Compton as the July issue of The Review was being printed. Professor Soderberg's new appointment will permit Dr. Jerome C. Hunsaker, '12, who has been head of both of the Departments of Mechanical and Aeronautical Engineering since 1933, to devote his entire attention to direction of the Institute's rapidly expanding program of research and instruction in aeronautical engineering, a field in which he has long been widely recognized as an authority.

The Department of Aeronautical Engineering grew out of the first professional course in that field which Dr. Hunsaker established at M.I.T. in 1914. Just before the beginning of World War II, the Wright Brothers Wind Tunnel was completed and with the beginning of hostilities it became one of the most important centers of research on aircraft design and performance.

The new supersonic wind tunnel now under construction for special research for the United States Navy will be operated by the Department of Aeronautical Engineering, which also has a full program of research on many other problems associated with flight.

Professor Soderberg, whose appointment as head of the Department of Mechanical Engineering became effective on July 1, has been deputy head of this Department for some time.

During the war Professor Soderberg served on the special committee on jet propulsion of the National Advisory Committee for Aeronautics. He also served on other government committees for studies of tank design and evaluation of gas turbine power plants for ships, and was consultant on the development and design of power plants in torpedoes. Since the war he has been a member of the subcommittee on turbines of the National Advisory Committee for Aeronautics and chairman of the panel for aircraft, fuels, and propulsion of the Scientific Advisory Board of the Army Air Forces.

The Class of 1902 observed its 45th reunion when members gathered at Osterville in June. Seated, left to right, are: Alfred W. Friend, Grant S. Taylor, Burton G. Philbrick, Chauncey P. Manning, Frederick H. Hunter; standing, in the second row, Wilbur L. Vatter, Cecil B. Annett, Lewis E. Moore, Edwin E. Nelson, J. Albert Robinson, Walter P. R. Pember Francis B. Galaher, Arthur L. Collier; and, in the last row, Lester C. Hammond, Albert A. Haskell, Charles W. Kellogg, Robert S. Baldwin, Stephen A. Gardner, John C. Fruit, William M. Bassett

Encore! Class of 1947

FINAL group in this Class (in addition to the February and June, 1947, graduates) were the 439 members of the Class of 9–47 who were awarded a total of 442 degrees at the commencement exercises which were held in Morss Hall, Walker Memorial, on September 26.

As one of the last "off season" graduating classes, resulting from the accelerated program of instruction which operated during the war, 30 doctor's, 158 master's, and 251 bachelor's degrees were conferred. In addition, three graduates received both bachelor of science and master of science degrees.

Everett M. Baker, Dean of Students, opened the commencement exercises with the invocation. Assisted by John W. M. Bunker, Dean of the Graduate School, President Compton presented degrees to the graduates. Dr. Compton also gave the commencement address which The Review is pleased to present on page 38.

Following the presentation of degrees, a reception was held in Morss Hall by President Compton for this new group of M.I.T. Alumni and those who were present at the exercises.

For Tomorrow's Physicists

THE Visiting Committee on the Department of Physics* held an all-day meeting on January 24, 1947, in which the morning session was devoted to a consideration of the undergraduate teaching, with particular reference to instruction given to students in other courses.

* Members of this Committee for 1946–1947 are: Francis J. Chesterman, '05, chairman, Roy D. Mailey, '04, A. Warren Norton, '21, James B. Fisk, '31, Percy W. Bridgman, Alfred L. Loomis, and Henry D. Smyth.

An inspection was made of the new Physics Laboratory and the teaching rooms made available by the moving of the Department of Geology. The Research Laboratory of Electronics and the Laboratory for Nuclear Science and Engineering were also visited by the Committee. After lunch, at which some of the problems were discussed, the Committee adjourned for a further review of the problems of the Department and its objectives.

Nearly 2,000 freshmen and sophomores and an increasing number of juniors and seniors from other departments had been receiving instruction in undergraduate physics. The new quarters, providing laboratory space for the Department on the third floor of Building Four, will make it possible to correlate the undergraduate activities more satisfactorily and to administer them better than in the past. A review of the subjects taught to the undergraduates indicated that no immediate changes were required, particularly since a committee, under the chairmanship of Professor Hans Mueller, has been active in planning and carrying out changes in undergraduate work, and has recently evolved a more satisfactory arrangement of subject matter.

The Committee was greatly impressed with the organization of the two main research laboratories, which largely account for the graduate work: the Research Laboratory of Electronics, operated jointly by the Departments of Physics and Electrical Engineering, under the direction of Professor Julius A. Stratton, '23; and the Laboratory for Nuclear Science and Engineering (comprising the Radioactivity Center, the High Voltage Laboratory, the Cosmic Ray Laboratory, and the theoretical group) directed by Professor Jerrold R. Zacharias.

The fundamental conception of these two laboratories, involving close co-ordination with the work in other

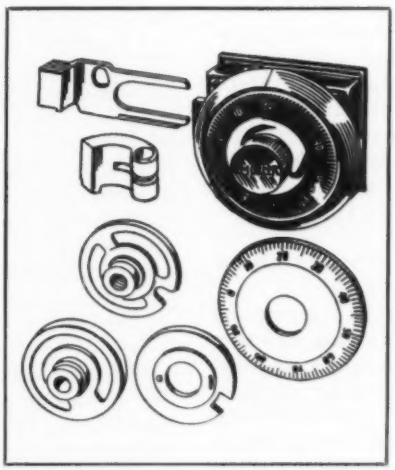
(*Continued on page 46*)

BUSINESS IN MOTION

To our Colleagues in American Business . . .

There is a well-known combination lock for safes and vaults that employs five different Revere Metals, as follows: 1, 70-30 Cartridge Brass for the dial flange; 2, Commercial Bronze, 90%, for case, case lid, and bolt; 3, Heavy Leaded Brass for tumbler parts and other items, including dial, requiring exceptional accuracy; 4, Free Cutting Brass in Rod and Extruded Shape, for the machined and knurled head, and for the angle bar; 5, Forging Rod, for the tumbler driver. Each of these was chosen because it offered the specific qualities needed.

Before specifying the Revere Metals for this lock the manufacturer studied their qualities and characteristics with great care, making use of our knowledge as well as his own. Thus he was able to make accurate and successful selections, draw up tight specifications, and be sure of meeting not only the requirements of fabrication methods, but also assure strength, long life, and dependable operation of the finished locks.



Revere produces many Revere Metals in order to give manufacturers the opportunity to match materials and requirements with the utmost accuracy. Each metal is made in several different forms or shapes. Variations in temper and finish are also offered, because these characteristics can be as important as composition. A slight change in temper, for example, may change a difficult and expensive drawing operation into an easy and economical one.

Revere feels that it has four fundamental responsibilities to industry. First, it must, and does, produce the finest possible non-ferrous metals, accurately controlled as to purity, physical characteristics, dimensions. Second, it produces these metals in such variety as to enable manufacturers to choose exactly what they need for their products and processes. Third, it produces them as promptly as possible, in order to assist in meeting production dates. Fourth, it makes available its complete knowledge of its metals.

In playing this quadruple role Revere is by no means alone. Any supplier of basic materials does likewise. Just as there are many coppers and brasses of different characteristics, so there are many alcohols, many woods, many plastics, many types of glass, and so on. Often the most important thing a supplier has to offer is what he knows about his materials. Out of long experience Revere has come to the conclusion that one of the most fruitful policies a manufacturer can adopt is that of using the brains as well as the materials of his suppliers.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

☆ ☆ ☆

Executive Offices:

230 Park Avenue, New York 17, N. Y.

(*Continued from page 44*)

courses, is eminently sound. The research in the Laboratory for Nuclear Science and Engineering, for example, brings together staff in the Departments of Chemistry, Electrical Engineering, Chemical Engineering, Metallurgy, and Mechanical Engineering. Moreover, the personnel in charge of each laboratory is drawn from the departments interested in the activities of that particular laboratory. This policy emphasizes collaboration and co-operation, rather than competition, and brings to each laboratory the talent which is available in the departments affected. The size of each laboratory has been fixed by the essential requirement that the permanent staff consist of professors of the Institute. The Committee was impressed by the number of investigations going on, as well as by the scope and magnitude thereof. Moreover, it is apparent that thoroughly competent people, outstanding in their knowledge and capabilities and forward-looking in their several branches of research, are engaged in this work at the Institute.

It is obvious that space, which will be provided in a new building, is needed for the Nuclear Science and Engineering Laboratory. It is hoped that this new construction will be undertaken shortly. On the other hand, in one of the temporary wartime buildings which is being used by the Research Laboratory of Electronics are many valuable tools and instrumentalities which could not be replaced even if the money to do so were available. These are housed in a temporary nonfireproof structure, which constitutes a potentially serious fire hazard. Certainly if the apparatus, mechanism, and tools in the temporary building were lost as a result of fire, a tremendous amount of time would be taken to replace them, and much research of importance would be delayed. The Committee recommends elimination of this potential hazard as soon as possible.

The Department has been able to retain, as research associates and research assistants, many young men who had served on wartime government research projects. Through these appointments the Department has been able to obtain a staff of well-trained and experienced men in the various experimental fields, and the character, quality, and amount of the work they are carrying on are ample evidence of the wisdom of this move.

In addition to the research associates and research assistants, there is a group of teaching fellows, on whom the Department is relying for much of the teaching in the undergraduate courses. The salaries of teaching fellows compare unfavorably with the salary scale of half-time and full-time research assistants. It is the conviction of the Committee that the Institute should provide better compensation for the teaching fellows. It is important that the morale of these men be high; the salary paid should be enough to enable them to live modestly. The problem is one which, in the opinion of the Committee, merits immediate solution, although the Committee realizes, of course, that this action must be co-ordinated with similar situations which may exist in other departments as well.

It is not possible, of course, to carry on the work of the two major laboratories except with outside assistance. The contract between the Institute and the Signal Corps, the Air Forces, and the Office of Naval Research supports the Research Laboratory of Electronics to the extent of $600,000 a year, and the Laboratory for Nuclear Science and Engineering is being supported by the Navy with a considerably larger sum. This is at once a strength and a weakness. It should be recognized, as the Committee is sure it has been by the Administration, that there is a considerable risk involved in undertakings of these magnitudes which rely so completely on external support for their operation. The second point which must be constantly kept in mind is that with such large research undertakings, the primary objective of the Institute, namely, teaching, might be lost sight of. The Committee is fully cognizant of the wise decisions which have been made with respect to these points.

Finally, the feeling of the Committee is that the whole situation is well in hand, that the quality of the work being done by the upper classes in experimental physics is well advanced, and that the attitude of the entire Department is one of forward-looking, eager enthusiasm for the work of the Department, with a well-balanced attitude of co-operation with other groups of the Institute.

Questions on Chemical Engineering

SINCE it last reported to the Corporation, the Visiting Committee on the Department of Chemical Engineering* has had interim meetings on November 10, 1944, and December 1, 1946. The Committee is glad to report that the Department of Chemical Engineering has come through the hectic war years with improved, rather than impaired, efficiency. Practically all the staff members, who took a large part in manifold technical activities pertaining to the war, have returned to the Institute in spite of attractive offers elsewhere. As a result, the Department is again well staffed with able young men in whom the Committee has entire confidence. Largely through the efforts of Bradley Dewey, '09, chairman of the previous Committee, the Department is now occupying and enjoying the full use of the new Chemical Engineering Building, which for the first time gives it a well-designed and integrated set of offices, laboratories, shops, and other facilities needed for Chemical Engineering instruction and thesis work. These facilities will permit the Department to handle at least 20 per cent more men than was possible with the prior setup and to do so with much greater efficiency.

There were three specific questions on which the opinion of the Committee was solicited. These questions and the recommendations of the Committee are as follows:

(1) Should the various Courses, such as Chemical Engineering, for which the demand is unusually heavy, be permitted to place limitations on the number of those entering the sophomore or junior year of these Courses, as was the practice before World War II?

In present circumstances, when the Institute as a whole is required to impose very severe restrictions on the num-

(*Continued on page 48*)

* Members of this Committee for 1945–1946 and 1946–1947 are: Robert E. Wilson, '16, chairman, Lammot du Pont, '01, John W. Livingston, '13, George O. Curme, Jr., and Harry C. Wiess. Percy C. Keith, Jr., '22, and William Welch were also members for 1945–1946. Charles A. Thomas, '24, and Frederic W. Willard are on the Committee for 1946–1947.

How many times each day does she open it?

FIELD tests made by General Electric refrigerator specialists show that a refrigerator door is opened 35 to 70 times a day, depending on the size of the family.

They need to know figures like these so that they can determine what will be required of G-E refrigerators over many years of use.

To make sure the door will give good service, for example, a robot testing device at the company's Erie, Pennsylvania, plant tirelessly opens and closes a G-E refrigerator as many times as the average family does over a 25-year span. Other tests check each unit for leaks, measure the parts to within a millionth of an inch, subject the finish to systematic torture.

By building with precision and testing with care, General Electric makes sure that every G-E product you buy will serve you long and faithfully.

You can put your confidence in

GENERAL ELECTRIC

THE INSTITUTE GAZETTE

(*Continued from page 46*)

ber of entering students, the Administration has not favored the reinstatement of prewar limitations on the numbers who would be permitted to take the more popular courses. As a result, the Chemical Engineering Department currently has about 70 per cent more students than it had before World War II, whereas its facilities were increased by about 20 per cent. The unusually large enrollment in Chemical Engineering this year has not constituted an undue burden because most of the increase is in the lower classes, whose numbers are taking relatively little professional work and no thesis work. If, however, this rate of increase is allowed to continue, the Department and the Committee believe that it will seriously impair the quality of the work the Department is able to accomplish. Just as the Institute must limit its numbers to keep from being overwhelmed, the Committee believes that the individual Departments should be permitted to impose reasonable restrictions on the number entering their Courses, giving due weight to the emergency situations confronting M.I.T. in common with all educational institutions. By channeling more students into the less crowded courses, a limitation on the number of students to be enrolled in especially popular courses might provide a means by which M.I.T. could efficiently accommodate a larger number of students.

(2) After the present emergency peak has been passed, does the Committee favor limitation of the number of the students in the Department to the number for which the present buildings were designed (representing an increase of 20 per cent beyond prewar enrollment)?

While staff members of the Department were inclined to favor such a postemergency limit, the Committee is of the opinion that both the supply of qualified students and the demand for M.I.T. Chemical Engineering graduates will be at least double the prewar demands for many years to come. Even this does not include prospective expanded demands for graduate courses from foreign sources and from our own Army and Navy. The Committee recognizes that there are advantages in limitation of size which enable a closely knit group of men to develop better *esprit de corps*. At the same time, the Committee feels that the Department will not be doing the best over-all job it can for prospective students (or for science and industry) if it does not make its plans to care for more than a 20 per cent increase from the prewar levels. The serious difficulty in securing the capital funds for expanding the facilities of this and other departments of the Institute is recognized by the Committee. It is suggested that by using certain facilities for a larger number of hours during the day, by making provision for fuller operation of the Institute facilities during the summer, and with necessary expansion of the staff the Department can provide outstanding Chemical Engineering education to a substantially larger number of students than the proposed 20 per cent increase above prewar numbers. The day has probably passed when there is justification for operating the very expensive facilities of our technical schools on the basis of seven or eight hours a day, in many cases for only 36 weeks a year, although teaching must not be adversely affected by more efficient use of physical facilities.

(*Continued on page 50*)

A Threefold Service to Tool Engineers

SIZE CONTROL CO.
2528 Washington Blvd., Chicago 12, Illinois
Phone: Monroe 6710

Originators of *REVERSIBLE THREAD GAGES* that combine maximum economy with precision. Still in service are *Size Control* reversible plug gages that have been ground back three times on leading edge at both ends . . . six gages in one at no extra cost!

REVERSIBLE PLUG GAGES
(Pat. appl. for)

Threaded

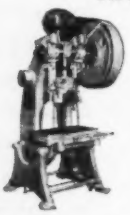
Plain

Plug Gages	*Ring Gages*	*Measuring Wires*
Plain Reversible	Plain Ring	
Thread Reversible	Thread Ring	Thread Wires
Taper-Flat-Special	Taper-Specials	Gear Wires
		Special Wires

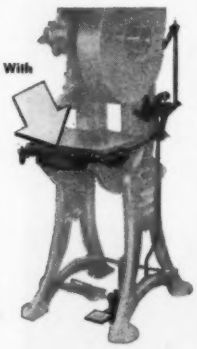
Tool Steel – Chrome – Tungsten Carbide – Stellite – Sapphire – Gage Sets Drill Sets – Number Sets – Fractional Sets – Dowel Pins – Centerless, Thread, Cylindrical Grinding.

WALSH PRESS & DIE CO.
4755 W. Kinzie St., Chicago 44, Illinois
Phone: Esterbrook 6700

HIGH PRODUCTION INCLINABLE PUNCH PRESSES
6 to 80 tons capacity



With



WALSH POWER PRESS SAFETY DEVICE with non-repeating attachment . . . saves fingers and hands . . . can be fitted to any make of power press . . . simple, foolproof.

PUNCH PRESSES – KICK PRESSES – DEEP DRAW PRESSES – SAFETY DEVICES – STOCK REELS

WACKER SALES DIVISION
35 E. Wacker Dr., Chicago 1, Illinois
Phone: Central 0375

Complete Gaging Source in ILLINOIS – WISCONSIN – IOWA area for

B. C. Ames Co.
Dial Indicators, Gages

Brush Development Co.
Surface Analyzers, Oscillographs

Riehle
Material Testing Equipment

Webber
Gage and Angle Blocks

Gem
Toolmaker's Indicators

Ferriot Bros.
Air Tools, Rotary Files

Waltham
Spline Gages, Master Gears

Suman
Snap Gages

DIVISIONS OF
AMERICAN GAGE & MACHINE CO.
Engineering Representatives in Principal Cities

AMERICAN TELEPHONE & TELEGRAPH CO.
AND ASSOCIATED COMPANIES

BELL SYSTEM

"I help make your telephone service the world's best"

"Long before most of you were born—back in 1877—I started making telephone equipment for the nation.

"As the manufacturing and supply member of the Bell Telephone team, I've *always* had a lot to do with making your service the world's best—at the lowest possible cost.

"The close teamwork made possible by my being a part of the Bell System was never more important than today—in helping to meet record demands for telephone service.

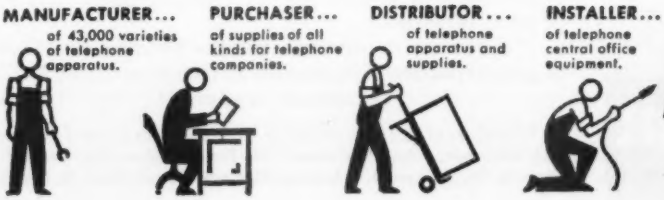
"My name is Western Electric."

MANUFACTURER... of 43,000 varieties of telephone apparatus.

PURCHASER... of supplies of all kinds for telephone companies.

DISTRIBUTOR... of telephone apparatus and supplies.

INSTALLER... of telephone central office equipment.



Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

DESIGNED BY CURTIS—
MADE BY CURTIS . . .

to meet a specific demand for a light duty *quality* joint where cost is a prime factor.

Utilizing an ingenious patented design, Curtis Engineers have developed a ball-type universal joint that combines *reduced friction* with *lower production costs.* These lower costs are being passed on to the user.

Many universal joint applications do not demand heavy duty, higher priced joints. If your problem is transmission of light torque loads around corners, or from one member to another which is slightly out of line, this new Curtis ball-type universal joint is the solution, with considerable savings in cost.

Specifications:— Curtis Ball-Type Universal

Steel forks bearing on a bronze ball, with heat-treated centerless ground pivot bearing pins. Large pin provided with oiler to enable proper lubrication of all bearing points. Ball surface offers minimum of friction loss, insuring long life for light load transmission or for hand operated controls.

Available now in ½" and ¾" sizes — other sizes in production.

DEPT. B-5

CURTIS UNIVERSAL JOINT CO. INC.

THE INSTITUTE GAZETTE

(Continued from page 48)

(3) Should the Department of Chemical Engineering co-operate with other departments in establishing a graduate course in nuclear engineering? Such a course would probably combine several months of specialized training with a practice school type of work in connection with a plant such as Oak Ridge, or Hanford, or possibly with one of the regional nuclear laboratories.

After considerable discussion, and with the concurrence of Charles A. Thomas, '24, who is particularly familiar with these fields, the Committee recommends that the Chemical Engineering Department co-operate with other Institute departments in offering such a course as soon as the necessary details can be worked out.

More Men; More Homes

THE Visiting Committee on the Department of Building Engineering and Construction * met with the staff on January 10, 1947, at the Institute. It reviewed the report of the previous Visiting Committee, which met on January 3, 1945, and was pleased to find that several of the recommendations of that Committee had either been adopted by the Administration or were in the process of fulfillment. The establishment of graduate work in the Department leading to the degree of master of science in Building Engineering and Construction was reviewed and approved.

The present curriculum of the Department was discussed, and the recommendations recently made to the Undergraduate Courses Committee for extension of the time allotted to the subject of materials were approved as desirable. With these changes the curriculum seems to be quite fundamental and broad and to possess all the characteristics of a sound, basic engineering course, as well as the necessary professional subjects to train students for some phase of the building industry.

Provision is made for graduate study in the fields of structural design, materials of construction, and building management. Students who elect to pursue studies in these fields should be well equipped for engineering, for work in the field of materials of construction, or for building management. It is the wish of the Department that programs of graduate study include approved graduate courses in such subjects as mathematics, theory of elasticity, theory of structures, photoelasticity, structural laboratory, chemistry, physics, and business administration, depending upon the field of interest selected by the student. The Committee recommends that the quota of graduate students assigned to the Department be increased in so far as commensurate with the number and quality of staff members who may be appointed in the future. The Committee feels it is highly desirable that the Administration give due consideration to such expansion when it is needed.

The increase in registration in the Department follows a general pattern of increase in all Departments at M.I.T.

(Continued on page 52)

* Members of this Committee for 1946–1947 are: Harry J. Carlson, '92, chairman, John H. Hession, '13, Percy Bugbee, '20, Francis A. Barrett, '24, Thomas D. Cabot, Lou R. Crandall, and Henry R. Shepley.

History-making boiler plants

Visualize a typical home-heating boiler and then imagine the kind of heating plant the Empire State Building would require. Now really let your imagination go and conceive a single central heating plant that would heat not only the Empire State Building but also the Chrysler Building, Radio City, Grand Central Station, Pennsylvania Station, the Waldorf-Astoria, the Commodore and literally hundreds of other structures — theaters, department stores, hotels and commercial buildings of all types and sizes.

Yet that job is the routine task of the Kips Bay Station of the New York Steam Corporation . . . the largest central heating plant in the world.

Perhaps the most surprising thing about Kips Bay is that it does its huge job with only five boilers . . . three were installed in 1926 when the station was built, the fourth went into service a year later and the fifth in 1930. All five boilers were designed and built by Combustion Engineering.

At the time the fifth boiler was projected, steam demand was increasing rapidly and the objective was maximum capacity from the available space. C-E met this objective by designing a boiler which, while occupying the same building area as each of the original boilers, was capable of producing nearly three times as much steam. Shortly after its installation this boiler set a new record when it averaged more than 800,000 pounds of steam per hour for a full month of continuous operation.

The association of C-E equipment with Kips Bay and many other boiler plants that have made history in the field of steam generation speaks for itself. The experience, special skills and advanced engineering which have brought about this association are applicable to your steam problems, whether your plant be large or small.

These three factors are the unwritten plus-values in every C-E contract —

Knowledge — *to solve today's, and tomorrow's, steam generating problems.*

Experience — *to interpret, from a world-wide background in every important industry, the specific needs of each installation.*

Facilities — *to manufacture complete steam generating units for every capacity from 1000 pounds of steam per hour up to the largest.* B-140

COMBUSTION ENGINEERING

200 MADISON AVENUE • NEW YORK 16, N. Y.

THE INSTITUTE GAZETTE

(*Continued from page 50*)

The Committee calls attention to the fact that the demands for graduates with the training provided by the curriculum will be high for quite a number of years because of the tremendous backlog of construction work. Because of present trends of construction it is highly desirable that a considerable number of trained men be fed into the industry from courses such as this. To do this means that the quota for the Department be raised to 20 or 30 per year and held at not less than 20 for some time to come. This in turn will, of course, mean some increase in staff as soon as competent men can be found. The Committee is particularly impressed with the fact that the present staff combines technical training with practical experience to a high degree, and any additions to the staff should continue that trend.

A review of the departmental research projects indicates that the staff is cognizant of the fundamental importance of research in the fields of materials and methods. It is hoped that open researches of the type now being conducted by the staff in the Department will continue, so that the Institute may be a place of advanced study in the various fields of the industry.

The Committee reviewed the space requirements in the Department as presented to the Administration under date of November 15, 1945, with subsequent revisions. With increased registration and the growth of graduate work it is important that the suggested space requirements be given consideration. The Committee recommends that the masonry materials research laboratory be expanded as soon as possible. With the expansion of enrollment it is highly desirable that additional space be made available for drafting purposes. The plastics materials research now being carried on in a temporary building is a continuing study which will justify the establishment of permanent space. The Committee assumes that the Administration is aware of these suggested space requirements for the Department and urges that they be given careful consideration.

It has been the intention of the Department, as reviewed by several Visiting Committees, to attempt the inception of a building construction and materials exhibit somewhere on the property of the Institute. The Committee is sympathetic with the general purpose of such an exhibit and suggests that it include not only actual construction projects for the training of students but also areas in which materials and their uses (as well as various details in the accomplishment of certain objectives) be exhibited. Usefulness of this exhibit to the students in Courses I, IV, and XVII, as well as to the architects, engineers, and contractors of Greater Boston, and to the general public, cannot be overlooked. Such an exhibit under the management of the Institute would be highly desirable. The Committee felt that the actual cost of constructing and furnishing materials and labor for the building and the exhibits therein could, and should, be carried by industry, but that the Institute should make land available as well as furnish the light, power, and general supervision of the project once it has been started.

(*Continued on page 54*)

Santa Fe Railway—Cajon Pass, California
POOR & COMPANY
CHICAGO
Manufacturers of Railway Equipment used by Railways throughout the world

Delaware Hospital, Wilmington, Delaware

Heated by 6-zone Webster Moderator System of Steam Heating. Completed in 1942. Unit No.1, center, occupied in 1940. Architects: Massena & duPont, Wilmington. Consulting Engineers: Jaros, Baum & Bolles, New York. General Contractor: Turner Construction Co., Philadelphia. Heating Contractor: Benjamin F. Shaw Co., Wilmington.

Hospital Saves on Cost of Heating

When a hospital spends in the neighborhood of $30,000 annually for fuel oil, that's big business. It calls for a "controllable" steam heating system and careful heating plant operation to effect maximum economies.

The outstanding heating record of the new Delaware Hospital began with a Webster Moderator System designed by the well known New York engineering firm of Jaros, Baum and Bolles. It included installation by a competent heating contractor.

Continuity of operating experience is provided by Chief Engineer Carl A. Baehr, who has been with the new Delaware Hospital from the beginning. Let Mr. Baehr tell you about some of the heating economies.

Only 3 Traps Replaced in 7 Heating Seasons

"Out of 1,981 Webster Radiator Traps in use, only three have required new thermostatic interiors in seven years of service. The Webster Radiator Supply Valves have been completely satisfactory.

"We receive no more than six legitimate heating complaints a year, and correction is always promptly made.

Good Operation Saves

During fuel rationing we effected a number of operating economies. Stairway radiators were turned off. Radiators in the clinics, X-ray laboratory, solariums and business office were shut down at 4 p.m. and turned on at 8 a.m. This manageability is characteristic of modern steam heating systems.

"Sometimes an unusual amount of heat is required in a particular room for a limited time. Instead of turning the Variator to full heat with consequent overheating of other rooms, we remove the Webster Metering Orifice from the radiator supply valve in less than three minutes. Later it is replaced."

The Delaware Hospital was only partially completed at the time fuel rationing went into effect. It was estimated that the completed Hospital would require 620,000 gallons of fuel oil per year. Based on this estimate, the fuel rationing board allotted 500,000 gallons of oil per year for all purposes—heating, sterilizers, laundry, kitchen equipment. Fuel consumption records show that the Hospital did not require a supplementary ration at any time during fuel rationing. The Webster Moderator System saves fuel by keeping radiators comfortably warm. Instead of 212 degrees, the average surface temperature of radiators is 185 degrees, 150 degrees or even as low as 90 degrees, depending on the need for heat.

Let Webster experience help you in your heating system management problems. The service of long-time Webster Representatives and the performance record of proven Webster Heating Systems is a combination that means comfort and economy.

WARREN WEBSTER & CO., Camden, N. J.
Representatives in principal U. S. Cities : : Est. 1888
In Canada: Darling Brothers, Limited, Montreal

WEBSTER
MODERATOR
CONTROL
"Control-by-the-weather"

THE INSTITUTE GAZETTE

(*Continued from page 52*)

The Committee recommends that the Administration consider the initiation of such a project.

The importance of placement training for the students in this Department was again discussed and stressed by the Committee. The Committee recommended that steps be taken as promptly as possible to set up contacts for such training during the summers between the academic years. It was pointed out that the curriculum calls for attendance at summer camp between the second and third years of the Course. This makes only the summers between the freshman and sophomore, and the junior and senior years available for this type of work. However, this plan works well with the requirements for the Reserve Officers' Training Corps camp, which is scheduled the first half of the summer between the second and third years. Inasmuch as students are not normally required to indicate their choice of courses until they register for the first term of their sophomore year the summer between the freshman and sophomore year does not present as feasible a period as could be wished for placement training. Nevertheless, the Committee recommends that the Department set up placement training between the freshman and sophomore years for those students who indicate their interest in such training when enrolling in the Department during the freshman year. The main portion of placement training would have to be given in the summer between the junior and senior years and the plan which the Department followed prior to World War II should be enlarged in its scope until it becomes possible to require one summer of such placement training as a part of the curriculum.

The Committee visited the Solar Energy Building, the Building Materials Laboratories, and the Plastic Research Laboratories, and was impressed with the fundamental character of the work being done in these fields. It is hoped that other research projects similar to those viewed will be arranged for in the future.

New Concept of R.O.T.C.

THE desirability of making some changes in the Reserve Officers' Training Corps program, with a view to effecting better co-ordination of the educational programs and aims of the educational institutions with those of the Reserve Officers' Training Corps, was discussed at length when the Visiting Committee on the Department of Military Science and Tactics * met with officers of the Institute and of the Department at the Harvard Club of Boston on the evening of December 2, 1946. Thus the Committee gave consideration to Reserve Officers' Training Corps matters of national scope, as well as to the more specific problems at M.I.T.

(*Continued on page 56*)

* Members of this Committee for 1946–1947 are: Thomas C. Desmond, '09, chairman, Frederick S. Blackall, Jr., '22, Colonel William F. Heavey, '22, Colonel Benjamin S. Kelsey, '28, Lieutenant General J. Lawton Collins, J. Willard Hayden, and Major General Horace L. McBride replacing former member Major General Ira T. Wyche.

ATLANTA
BALTIMORE
BUFFALO
CHICAGO
CINCINNATI
CLEVELAND
COLORADO SPRINGS
COLUMBUS
DALLAS
DAYTON
DENVER
DETROIT
HARTFORD
HOUSTON
INDIANAPOLIS
KANSAS CITY
LAWRENCEVILLE, N. J.
LOUISVILLE
NEW HAVEN
OMAHA
PHILADELPHIA
PITTSBURGH
POTTSTOWN, PA.
PRINCETON
PROVIDENCE
RICHMOND, VA.
ROCHESTER
ST. LOUIS
SYRACUSE
WASHINGTON, D. C.

BROOKS BROTHERS' Travelling Representatives will visit 30 places during the Fall 1947 season with comprehensive assortments of our celebrated Ready-made Clothes and Furnishings. If you live in or near one of the cities listed...and are interested in inspecting our local showing or ordering anything from our representatives...write for a copy of our Fall 1947 Itinerary, showing exactly where and when our men will be located.

ESTABLISHED 1818

Brooks Brothers
CLOTHING
Men's Furnishings, Hats & Shoes
OFFICERS' UNIFORMS, FURNISHINGS AND ACCESSORIES
346 MADISON AVENUE, COR. 44TH ST., NEW YORK 17, N.Y.
46 NEWBURY, COR. BERKELEY STREET, BOSTON 16, MASS.
LOS ANGELES • SAN FRANCISCO

The growing company soon leaves its own back yard. When it does, the diversified consulting laboratory is ready to help it explore new areas and meet technical and economic opportunities.

Arthur D. Little, Inc.

Chemists — Engineers

30 Memorial Drive

Cambridge 42, Massachusetts

SIMPLEX-ANHYDROPRENE

A modern design in wire and cable construction featuring:

- **SIMPLICITY**
  ANHYDROPRENE construction consists of a tinned copper conductor, ANHYDREX insulation, and a thin jacket of neoprene.
- **IMPROVED PROPERTIES**
  ANHYDREX insulation resists moisture more effectively than any other rubber insulation. The cured-in-lead neoprene jacket provides protection from oil, acids, sunlight and flame. It eliminates the need for outer braids.

  ANHYDROPRENE wires and cables are lightweight, have small diameters, and can be easily pulled into ducts or conduit.
- **VERSATILITY**
  ANHYDROPRENE wires and cables can be used for plant and shop wiring, instrument wiring, control circuits, pole line risers, transformer leads, and power circuits.

SIMPLEX WIRE & CABLE CO.
79 Sidney St., Cambridge 39, Mass.

HEVI DUTY

Hevi Duty Electric Co.
Surges Transformers

With the acquisition of the Surges Electric Company of Milwaukee, Hevi Duty can now offer quality dry type air cooled transformers with or without tap changing switches as well as special transformers for special requirements. An accelerated program of modernization will present opportunities for increased production and good delivery schedules.

Write for Bulletin S-4611

HAROLD E. KOCH '22, ***President***

ELTON E. STAPLES '26, ***District Manager, Cleveland***

HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES **HEVI DUTY** ELECTRIC EXCLUSIVELY
MILWAUKEE 1, WISCONSIN

THE INSTITUTE GAZETTE

(*Continued from page 54*)

In the preparation for modern war, serious consideration must be given to the needs of research laboratories in educational institutions, industrial concerns, and the armed forces. The Army's need is for research personnel, well-qualified officers for line branches of the Army, and a limited number of graduate engineers and scientists for the combat arms, for use in helping to solve technical problems arising in connection with field operations. The logical source of research personnel for the Army is the Reserve Officers' Training Corps units established in technological institutions, which institutions are also the logical sources of new technical personnel for industrial and educational institutions. It is recognized that the assignment of highly trained engineers and scientists to organizations in which full use is not made of their technical abilities will result in loss to the country of the time and energy spent in training such personnel. To meet the Army's needs more satisfactorily, it may, therefore, be desirable to establish separate categories of Reserve Officers' Training Corps students, particularly in the technical fields.

The Committee realizes that specialized courses for engineering students may not be advisable for every engineering Reserve Officers' Training Corps unit, and that probably only some of the larger engineering schools may be expected to provide reserve officers especially qualified in difficult research and development work.

In considering these problems, the Committee discussed the possibility of eliminating branch designations for all officers of the Army. If such a plan should be adopted, the Committee feels that officers with definite specifications should be developed in the Reserve Officers' Training Corps. For example, one category could be construction engineers; another, artillery commanders; and a third, highly skilled scientific and engineering graduates qualified for research and development work in fields in which war-making matériel should be developed.

It is the opinion of the Committee that if additional emoluments are provided for Reserve Officers' Training Corps students, it would be desirable to limit them to students in the advanced course. Such a limitation would permit available funds to be applied to men already committed to entrance into the Corps.

In view of the foregoing, the Committee recommends that the War Department be approached on the subject of forming a committee of civilian educators, representing leading technical institutions, and members of the Army to study the following problems relating to the Reserve Officers' Training Corps:

(1) The establishment of separate categories of Reserve Officers' Training Corps students, without regard to branch, to provide one group especially qualified in high-level research and development work and another for duty in positions and organizations whose primary interest would be administration or operations in the field.

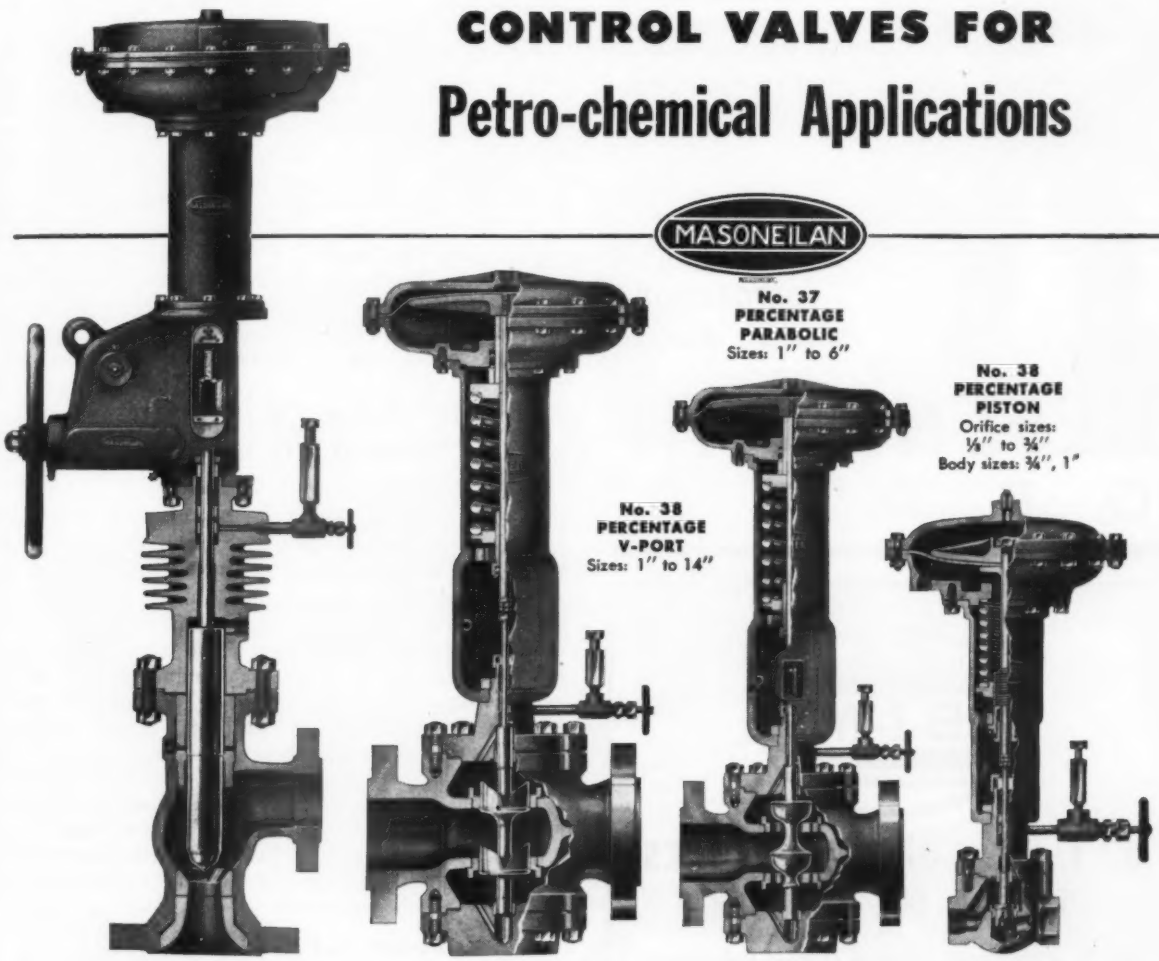
(2) The desirability of providing a limited number of graduate engineers and scientists for the combat arms of the Army, for use in helping to solve technical problems arising in connection with field operations.

(*Concluded on page 58*)

MASONEILAN

CONTROL VALVES FOR
Petro-chemical Applications

MASONEILAN



No. 7178—6A
Sizes: 2″ to 6″
Also available with expanded outlet

No. 37 PERCENTAGE PARABOLIC
Sizes: 1″ to 6″

No. 38 PERCENTAGE V-PORT
Sizes: 1″ to 14″

No. 38 PERCENTAGE PISTON
Orifice sizes: ⅛″ to ¾″
Body sizes: ¾″, 1″

No matter what the application, temperature, pressure, level and flow, there is a Masoneilan control valve designed to meet the requirements of the petro-chemical industries.

Masoneilan control valves are available in a wide range of types and sizes from 1/16″ orifice and up. Masoneilan Engineers are available for engineering assistance on your control valve problems.

No. 107
Orifice sizes: 1/16″ to 7/64″
Body size: ½″

MASON-NEILAN REGULATOR CO.

1190 ADAMS STREET, BOSTON 24, MASSACHUSETTS

New York • Philadelphia • Pittsburgh • Cleveland • Chicago • Tulsa • Buffalo • San Francisco
St. Louis • Houston • Los Angeles • Atlanta • Mason Regulator Co. of Canada, Ltd., Montreal and Toronto

Time for New Products

Industries looking to the future have new products on the drawing board today. Gears for the production machinery and gearing within the product can be handled most effectively by the gear experts at Diefendorf.

•

DIEFENDORF GEAR CORPORATION
Syracuse 1, New York

DIEFENDORF GEARS

BOSTON INSULATED WIRE B.I.W. & CABLE COMPANY

B. I. W. COAXIAL CABLES TRADE MARK CO-X

B. I. W. offers a complete range of types and sizes of coaxial cable for high frequency applications:

— Small flexible, low capacity (5 to 10 uuf/ft.) for internal wiring, patch cords, etc.

— Coaxial and Twin-axial weatherproof cables for antenna lead-in and other outdoor uses.

— Flexible standard synthetic insulated cables for electronic apparatus.

— Heavy duty, high power, flexible or semi-rigid transmission line.

All of the above can be supplied with special fittings and junctions for connections to panels or rigid lines.

BOSTON INSULATED WIRE AND CABLE COMPANY
BOSTON 25, MASSACHUSETTS

THE INSTITUTE GAZETTE

(*Concluded from page 56*)

(3) The development in the Reserve Officers' Training Corps of officers with definite specialties, should branch designations be eliminated from the Army.

(4) The proper application of any increased emoluments for Reserve Officers' Training Corps students, by limiting such aid to students of the advanced course, senior division.

The Committee further recommends that the Institute make an effort to provide storage space for heavy equipment to be used in the advanced course, and that this space be of suitable construction to permit use by a class in cold or inclement weather. It is suggested that the Institute endeavor to obtain from military reservations in the First Service Command surplus buildings not required for housing of personnel, which could be moved to M.I.T. for this purpose.

The Committee further recommends that the Institute provide, either by extension of existing facilities, or by new construction, increased space in the Institute rifle range to provide a minimum of 10 firing points.

AIR POWER RELATED TO CONSTRUCTION POWER

(*Concluded from page 28*)

even if reconstruction of existing facilities were to become necessary, the over-all gain would be overwhelming since it certainly would be easier to provide soft runways on all our airfields than to make all of them five or ten times as strong. Regardless of the type of runway surface required, successful development of the track landing gear is a desirable goal to attain for economic as well as for engineering reasons. Such landing gear would make possible the construction of at least five new airfields, adequate to support heavy tracked aircraft, at a cost not exceeding that now required for one airfield designed to support heavy planes of conventional types. In addition, airfields could be built by existing methods and techniques, and the day when larger and heavier construction equipment becomes essential for the construction of airfields would be postponed.

Mobility and Flexibility Insured

In summary, expanding air power depended upon and was made possible by increasing construction power employed in its direct support. In the future, factors of strategy and economy are likely to force the development of even larger aircraft, wherein the limiting factors appear to be related to pavement, tire, and landing-gear problems. Until these problems are solved, the mobility and flexibility of our strategic air arm will be restricted. The solution appears to lie in concentrating aggressive research on the development of stronger and more durable pavements, and improved landing gear for aircraft; and in maintaining, within the regular and civilian components of the United States Air Force, a construction organization second to none in professional competency, and capable of accomplishing the rapid construction of suitable air bases on our strategic frontiers when, and if, needed.

here's what PACKARD CLIPPER owners have to say about . . .

VENTALARM ®

COMMENTS: YOU MAY USE MY NAME AS ONE WHO BACKS VENTALARM TO BE AN IMPROVEMENT WHICH SHOULD BE STANDARD EQUIPMENT ON ALL MAKES OF CARS

Mr. Kosacek
Springfield, Mass.

I wouldn't be without it and any manufacturer of automobiles who does equip his car with this gadget and doesn't do so, in my opinion at any rate, doesn't belong in the automobile manufacturing business and will probably have to get out of it sooner or later.

CHAMPION LAND WORKS
Jasper Marsh
President

COMMENTS: A DEFFINATE ASSET — FOR CARS PARTABLE MOTORING

Mr. Sanders
Newburyport, Mass.

COMMENTS: My wish is that every Car Made had it as Standard equipment

Mr. Wolfenden Boston, Mass.

COMMENTS: very good and essential to all cars I wish I had them on my trucks

Mr. Johnson Newtonville, Mass.

COMMENTS: I believe it is a good safety device

Mr. Smith
Lawrence, Mass.

COMMENTS: Desired to fill her up till the gasoline steps blowing. Like it very much and it is a money saver.

W. H. Eddy
Boston, Mass.

COMMENTS: As essential to a car as traffic lights. Have one in my oil tank.

Mr. McDonough
Boston, Mass.

These are comments selected at random from 500 replies received in a recent survey among Packard Clipper owners.

VENTALARM Whistling Fill Signal is standard equipment on fifteen makes of automotive vehicles.

[*In the oil heating field, over 1,000,000 homes are now equipped with Ventalarm installation.*]

SCULLY SIGNAL COMPANY
88 FIRST STREET, CAMBRIDGE, MASSACHUSETTS

THE
MURRAY
PRINTING
COMPANY

A Complete Printing Organization
Letterpress :: Offset :: Binding

18 AMES STREET
CAMBRIDGE

TRADE MARK
HEVI DUTY
REGISTERED U S PAT OFFICE

Hevi Duty Electric Co.
Electric Heat Treating Furnaces
Surges Dry Type Transformers
MILWAUKEE 1, WISCONSIN

Hevi Duty Precision Electric Heat Treating Furnaces are built in a large variety of types and sizes — for many heat treating operations — with temperature ranges to 2500° F. (1371° C.). They are standard production equipment in many national industrial plants.

Write for descriptive bulletins

HAROLD E. KOCH '22, *President*

ELTON E. STAPLES '26, *District Manager, Cleveland*

HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY
MILWAUKEE 1, WISCONSIN

RESEARCH FOR EDUCATION

(*Concluded from page 31*)

from academic duties to undertake the research. Out of approximately 200 academic staff members working part time on sponsored research, less than 20 are receiving supplementary compensation. Those who receive this extra compensation agree, for the period they receive it, to forego their privilege of engaging in outside consulting.

Other Sponsored Research Policies

Other more detailed tests which are applied to sponsored research at M.I.T. include the following:

(a) Some department or group of departments (or an academic organization such as the Research Laboratory of Electronics) must be willing to accept responsibility for the project and must have available senior staff members who are free and willing to oversee the project. Contract research is thus under the jurisdiction of the academic departments.

(b) It must be possible to staff the project in accordance with the Institute's prevailing personnel policies.

(c) It must be possible to staff the project without handicapping the educational program either by overloading the staff or by diverting from the educational program the proper amount of attention and interest.

(d) The project must come within the volume of research (measured in dollars, space, personnel, and required amount of administrative attention) which the Institute can appropriately undertake. It must fit into a balanced over-all program and it must be of sufficient importance and interest to be taken into the Institute.

(e) Final approval of the project rests with the academic dean who has jurisdiction. If the project is borderline and the dean has doubts whether it meets the tests and principles laid down, he will bring it before an administrative committee composed of the president, the vice-president, the dean of engineering, the dean of science, and the director of the Division of Industrial Coöperation.

Reduced to a single statement, these principles say in effect that the consideration, acceptance, and priority of any sponsored research project are governed by the extent to which the proposed activity will carry forward the educational objectives of the Institute. Only under conditions of great emergency will projects be accepted which do not contribute to the advancement of educational objectives or of scientific knowledge or of engineering art. We believe that only by strict adherence to these principles can a large volume of sponsored research be undertaken and still retain the integrity of M.I.T.'s educational program. We believe further, however, that sponsored research can be carried out in conformance with these general principles.

In conclusion I would reiterate that research, aimed at advancement of knowledge or development of its practical applications, is both a method of advancing knowledge and a method of teaching and that it must be both when carried on in collaboration with students. In meeting this educational test our research programs must also help to create that subtle kind of environment where scholarship and creative activity flourish and great minds feel at home. The creation of this environment is a major task of our engineering institutions.

Are You Making the Best Use of Your Life Insurance?

The cash received from your insurance does not in itself guarantee protection for your heirs. It must be wisely invested to produce a regular income in order to provide its maximum usefulness. The insurance companies themselves offer certain options for paying out the proceeds of policies on an installment or annuity basis, or for paying interest on the proceeds. These options are desirable in many cases. But often it is preferable to have a more flexible arrangement to meet special conditions.

In such cases a Life Insurance Trust, created to receive the proceeds of your policies, can contain the discretionary provisions you desire.

Other property may be added to such a trust so that it may become the principal means of managing and distributing your property.

We invite your inquiries.

The

New England Trust Company

135 DEVONSHIRE STREET

At the Corner of Milk Street

BOSTON 7, MASS.

Member Federal Reserve System

Rogers Peet Overcoats!
"Good for years."

Styles for young men,
and men who never grow old

Good for years — and smartly styled — for you — whatever your years!

Finest imported and domestic woolens.

The smart individual styling of the *modern* Rogers Peet.

Our own careful, unhurried tailoring.

An investment in years of wearing pleasure — a worthwhile investment thanks to the *Values* created by the scale of our operations.

"Perfect fitting" is another experience you will enjoy here.

Rogers Peet Company

Makers of Fine Clothes

In New York: Fifth Avenue *at* 41st Street | Thirteenth St. *at* Broadway | Warren Street *at* Broadway | *And in Boston:* Tremont St. *at* Bromfield St.

OXYGEN FOR INDUSTRY

(*Continued from page 35*)

gasification to possible large-scale commercial realization in the United States. Interest lies both in the manufacture of gas at mine mouth with a volumetric heating value high enough to warrant pipe-line transmission, and in the utilization of coal for the production of "synthesis gas" to be converted into liquid fuels. Utilization of the principle of the fluidized catalyst bed, developed in the United States ("jiggling" as the devotees call it), seems likely to play an important part in both the coal-gasification and the conversion stages of these developments and is already being extensively studied in pilot-plant operations.

Progress in methods for producing low-cost, high-purity oxygen is of much more than academic interest, and already plans have been developed to manufacture low-cost, high-purity oxygen on a large scale. It is reported that, as a result of co-operative studies made by the Standard Oil Company of New Jersey and the Pittsburgh Consolidation Coal Company,[8] these companies plan to build a $300,000 pilot plant at Library, just outside of Pittsburgh. The pilot plant will have a daily yield of almost 2,500,000 cubic feet of gas from about 50 tons of coal. In the development of their Hydrocol process for economically producing natural gas from gasoline, Hydrocarbon Research, Inc.[9] also plans to produce about 40,000,000 cubic feet of high-purity oxygen daily by separation from air. The Synthol projects, Carthage Hydrocol, Inc. and Stanolind Oil and Gas Company, are also expected to be in operation soon.

While all this is happening aboveground, fires are burning underground in experiments on the conversion of coal to gas without mining. The Russian experiments, frequently in the press, have successfully used the alternating "blow with air — run with steam" technique of the water-gas process. Experiments in this country are being conducted by the Bureau of Mines and the Alabama Power Company at the Gorgas Mine near Jasper, Ala. After the general technique has been worked out, cheap oxygen might well be the key to the successful commercial operation of such underground gasification projects. Already it has been found that oxygen-enriched air improves the producer-gas type of operation being studied in Alabama.

Other Possibilities

Important as they may turn out to be, these schemes for coal gasification both above and below ground will not solve all of coal's problems, since without extraordinary transformations in our economy, solid coal will still be required for running most of the railroads, for making coke with which to make iron and steel, and for other fuel uses at locations not economically reached by gas pipe lines. New methods of mining are being studied to help solve some of the other problems, and while oxygen will not be involved directly, the resulting lower-cost coal may affect processes in which cheap oxygen will play a role.

(*Concluded on page 64*)

[8] "Coal," *Fortune*, March, 1947. Bland, William F. "Gasification of Coal May Foreshadow New Industry Replacing Oil Refineries," *National Petroleum News*, April 2, 1947.

[9] Keith, P. C., "Gasoline from Natural Gas," *Oil and Gas Journal*, June 15, 1946, p. 102.

He gave me a $64 answer!

I met this particular Major at "Willow Run"—that gigantic officers' mess in the Grosvenor House hotel in London.

He had just come back from duty in Germany, and we happened to relax near the same sofa on the balcony lounge. After the usual Army talk, the conversation sagged. To fill in, I asked him what he had done in civilian life.

I expected a one-word reply — but I got a $64 answer.

"I started out as an accountant," the Major said. "Worked at it for six years, but I was getting nowhere — and too slowly. So I decided I'd better dig in and figure out the next move. Being the methodical type, I wrote down my specifications for the ideal job. Well, first I wanted to be my own boss and be able to knock off for a little sailing or fishing when I felt like it. Then, I wanted my work to pay off to *me* in person. And I *didn't* want any slow moves up a ladder, or a business that needed a big investment to start.

"Doesn't that sound sort of impossible? But I stuck at it and checked off a long list of careers against my specifications.

"Only one job promised to fill my bill. It was — to my complete surprise—life insurance. Now I had never sold anything, mind you, but if selling was the one way to a combination of freedom and income, I would certainly try it. My company gave me a practical training course, and within a year I made just twice what I figured I'd be lucky to be making by that time. A good week of work meant good checks, and the renewals made every week's work pay off for years afterwards — something that's coming in mighty handy for my family right now while I'm away.

"That's how I got what I wanted. But oddly enough, it was something I hadn't planned on at all that made my job the best one in the world for me. It was the conviction that I was helping other people get what *they* wanted . . . independence, security. If you could visit just one of the families that are now living comfortably because of the life insurance I sold a young father, you'd know what I mean."

. . . . . .

P. S. Perhaps the Major's story can answer some of your career questions. It is typical of many service men who are now back with New England Mutual. For more facts and figures, write Mr. H. C. Chaney, Director of Agencies, New England Mutual Life Insurance Co., 501 Boylston St., Boston 17, Mass.

ROTO-TROL 940

Multi-Position Programming Float Control

Write for Bulletin 940

The 940 is ideal for complex control of multi-pump installations. Any desired number of starting and stopping positions for each pump. Any sequence of operation — more uniform flow through use of maximum number of pump combinations.

Other types of Roto-Trol Float Controls are also available

Water Level Controls Division of

HEALY-RUFF COMPANY

D. W. C. RUFF '07, *President*

771 HAMPDEN AVE. ST. PAUL 4, MINN.

CO_2

GAS . . . LIQUID . . . SOLID (Dry Ice)

THE LIQUID CARBONIC CORPORATION

3100 South Kedzie Avenue, Chicago 23, Illinois

U. S. A.

28 Producing Plants
More than 50 Distributing Points

CANADA

Halifax to Vancouver

OVERSEAS

England, Cuba, Mexico, Venezuela, Colombia, Trinidad, Brazil

Liquid **RED DIAMOND** *Gas and Dry Ice*

OXYGEN FOR INDUSTRY

(*Concluded from page 62*)

Of necessity this survey has been confined to a review of the larger new prospective uses for oxygen in industry. But many other important, if smaller scale, uses for this gas will undoubtedly be developed when oxygen of high purity is commercially available at low cost. The lower cost and high purity which modern methods make possible open up increasing uses for oxygen in old applications through the perfection of new techniques. Additional uses for oxygen may be expected in oxygen therapy, in the manufacture of explosives, in supplying secondary fuels in propulsion devices. We may also expect the mines to use large quantities of low-cost oxygen for the fusion piercing of taconite beds. This new method of making vertical blast holes may be of the greatest importance in the commercial use of the iron ore reserves on which this country may have to depend when the more accessible ores of the Mesabi Range are exhausted.

THE TREND OF AFFAIRS

(*Concluded from page 23*)

education and research studies are highly intriguing. Certainly any means which furthers the ability to visualize relationships expressed analytically, or which facilitates physical interpretation of mathematics will appeal to students of science and engineering.

Research attained an all-time high during the war when 2,250 laboratories financed by private enterprise were in operation. The full weight of the results of research thus conducted is not expected to be felt for several years. Most of the development was carried out by large firms whose products and processes will probably undergo substantial changes during the next few years. But when better and more useful products become available, the consumer, and those who carried out research, will be among those to gain most by past investigations.

Nonflowing, finely divided metal powders can be made to flow by waterproofing the individual particles. Condensation of moisture on the metal particles has been found to cause them to flow slowly, erratically, or, in some cases, not at all. In experiments, finely divided iron powder, typical of that generally considered unsuitable for metallurgy, was treated with a vapor of methyl chlorosilanes which increased the flow rate to 80 per cent of that for a standard silicon carbide powder.

SWISS AUTOMATICS

Rebuilding and Tooling Service

We have trained personnel and facilities for complete rebuilding and tooling of your Swiss Automatics and other type Swiss Machines.

YOUR INQUIRIES ARE INVITED

BORIS M. VOLYNSKY MFG. CO., INC.

311 West 66th Street New York 23, N. Y.

Safe . . . but are they Sound?

Sound investment management today is *more* than a full-time job for one person.

To make sure the securities you own are those of well-managed enterprises in forward-looking fields calls for teamwork by *many* persons thoroughly experienced in research and analysis.

No individual investor could hope to find the time to visit in person the managements of companies scattered throughout the United States . . . to gauge the progress of the arts and sciences as they may affect a particular concern or industry . . . or to sift the mass of available financial and business data.

When you open an Investment Management Account with Old Colony Trust Company, you obtain the services of an *experienced team*, constantly working for your investment guidance.

A request for our booklet, "INVESTMENT MANAGEMENT," will bring you information on our investment services.

WORTHY OF YOUR TRUST

OLD COLONY TRUST COMPANY

ONE FEDERAL STREET, BOSTON

T. JEFFERSON COOLIDGE, *Chairman, Trust Committee*

ROBERT CUTLER, *President*

Allied with THE FIRST NATIONAL BANK OF BOSTON

THE TRIAL IS NEVER OVER

GOOD-WILL is the disposition of the customer to return to the place where he has been served well—

U. S. Supreme Court.

TO OUR FRIENDS

We do not believe that any advertising copy man could have penned a neater and more trenchant definition than this decision of the Supreme Court.

It happens also to be the verdict which our customers have reached regarding their relations with us.

Your specific problems in technical reproduction work from the lowly blue print to the complicated offset printing of an engineering manual, will find their happy solution with us.

ELECTRO SUN COMPANY, INC.

Blue Prints — Photo Prints — Photo Offset

161 Washington Street **157 Chambers Street**

Grand Central Terminal Building

NEW YORK, N. Y.

A. L. Weil '01 **J. C. Duff '86**

TECHNOLOGY MEN . . .

CAMPUS ROOM

The Graduate House

Technology's Social Center

is the

HOME FOR YOUR CLASS FUNCTIONS

MENUS SUBMITTED ON REQUEST

Address: H. K. DOW

THE GRADUATE HOUSE

M. I. T.

Cambridge 38, Massachusetts

Tel. Kirkland 2680

COLLOIDS IN SCIENCE AND INDUSTRY

(*Continued from page 37*)

reaction of the silver ions with the bromine ions located in the surface of the particle, as shown in Fig. 1. Now it is exactly this phenomenon which is the basis for many very important industrial processes and applications.

A few examples are here pointed out. The surface charges which are carried by most dust particles, or small liquid globules, are used to good advantage to purify the air which otherwise would escape through the chimneys of industrial plants. Removal of smoke, dust, or other fine particles is accomplished by setting up a high potential electrostatic field in the chimney. The electric field is created by placing one electrode in the center of the chimney and the other electrode on the inside of the flue, and then applying a steady high voltage between these electrodes as illustrated in the diagram of the Lodge-Cottrell precipitator, Fig. 2. Flue particles which have a positive surface charge are collected at the cathode (or negatively charged electrode) whereas oppositely charged particles are collected at the anode. The removal of colloidal particles by this method is quite effective.

If a sheet of nickel is brought into contact with oxygen and carbon monoxide at a slightly elevated temperature nothing astonishing will happen. If the nickel is in the form of colloidal powder, however, carbon dioxide is formed by a process which chemists call heterogeneous catalysis. Again, as indicated in Fig. 3, it is the surface charge of colloidal particles which is responsible for formation of the new compound. A solid piece of coal placed in the mouthpiece of a gas mask would offer no protection to the person wearing it during exposure to poison gas. But if only a fraction of the carbon is used in the colloidal state, protection against poison gas can be achieved for several hours. As indicated by Fig. 4, the greatly increased surface of colloidal carbon particles is capable of removing particles of poison gas by virtue of the surface charges for the two particles. The effectiveness of certain clays and many synthetic resins, used for various purposes of purification, is based on the same phenomenon. The lives of many men, forced to abandon ships or planes at sea, have been saved by supplying them with cartridges filled with such substances through which sea water could be passed and made drinkable.

Seeing Is Believing

In the strictly scientific field colloid chemistry has also some very interesting and important contributions to report. Probably the most exciting and possibly far-reaching one is the application of a new ultramicroscopic technique in the study of elastic colloids, such as rubber and the synthetic plastics. This new development, which originated at M.I.T. and on which efforts are now being continued in collaboration with the Midwest Rubber Reclaiming Company, is based on work done several years ago with the electron microscope in the Institute's Department of Biology in collaboration with the Department of Chemical Engineering. The new technique, in which incident light is applied to an ultramicroscope, as shown in Fig. 5, permits direct visual or photographic study of the effect of time and temperature on substances exhibiting elasticity either at normal or at elevated temperatures. The changes which take place with time in

(*Concluded on page 68*)

The

RUMFORD PRESS

CONCORD
NEW HAMPSHIRE

WHERE

Printing

IS STILL A CRAFT

A Report

TO M.I.T. MEN

In 1917 Walker Memorial Building was opened, a gift from Alumni for the welfare of M.I.T. students. In addition to including offices for student activities and serving as a student social center, this building houses the dining service.

In 1946–47 nearly one million meals were served to staff and students. Morss Hall seats approximately 500 people. Thus, each chair served 2,000 people per year or 5.5 persons per day. We thank the Alumni for making these services possible.

WALKER MEMORIAL DINING SERVICE

• *M.I.T.* •

CAMBRIDGE 39, MASSACHUSETTS

A. W. BRIDGES, *Manager*

Doelcam Corporation

PRECISION INSTRUMENTS

GYROSCOPES — GYROSCOPIC DEVICES

DESIGN • DEVELOPMENT • PRODUCTION

437 CHERRY STREET, WEST NEWTON 65, MASS.

The TREDENNICK-BILLINGS CO.

CONSTRUCTION ENGINEERS ★ BUILDING CONSTRUCTION

K. W. RICHARDS '07 H. D. BILLINGS '10 C. C. JONES '12 F. J. CONTI '34

10 HIGH STREET ★ BOSTON, MASSACHUSETTS

WILLIAM D. NEUBERG CO., INC.

Chemicals

GRAYBAR BUILDING 420 LEXINGTON AVE.
NEW YORK 17, N. Y.
TELEPHONE LEXINGTON 2-3324
CABLE—"WILNEUBERG"

J. C. CORRIGAN CO., INC.
Conveyers
Engineers • Manufacturers • Erectors
Coal Handling Systems
Materials Handling Equipment
Portable Conveyors
Distributors for
Jeffrey Manufacturing Co.
Jeffrey Parts Carried in Boston Stock
41 Norwood Street, Boston 22, Mass.
Tel. GENeva 0800

Transits and Levels are used on all largest works and by U. S. Govt. for utmost precision. Rental Insts. *New catalog, just issued, sent gratis. A souvenir plumb-bob sent for 3¢ postage.*
BUFF & BUFF CO. Boston 30, Mass.
Henry A. Buff '05

William H. Coburn, '11 William F. Dean, '17

William H. Coburn & Co.
INVESTMENT COUNSEL
68 Devonshire St. Boston, Mass.

PRECISION-GAUGED HAIRSPRINGS
AND
FINE ROLLED WIRE
PRECISION PRODUCTS COMPANY
WALTHAM, MASSACHUSETTS
ROBERT I. BRADLEY '20

COLLOIDS IN SCIENCE AND INDUSTRY

(*Concluded from page 66*)

a sample of rubber, for example, are illustrated in the series of photomicrographs of Fig. 6. Changes taking place as a function of temperature are illustrated by the two photomicrographs of gutta-percha in Fig. 7.

When, as in the technique just described, it is possible to study microscopic changes in substances occasioned by changes in time, temperature, and other physical quantities, and when it is further possible to correlate observable changes with knowledge of the chemical composition

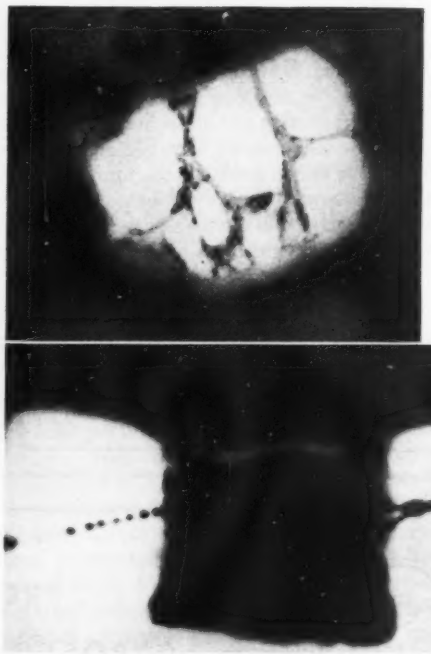


Fig. 7. Temperature effects on gutta-percha are illustrated by these photomicrographs made at 25 degrees C. (left) *and at 65 degrees C.* (*below*).

of the substance under investigation, it is logical to anticipate important advances from such research methods. Our anticipations find ready confirmation in recent studies. For example it has been possible to prove conclusively that elasticity is due to a well-balanced distribution of different molecular weight fractions of the same compound, or to the mixture of two compounds, one of which acts as a solvating agent for the other. Based on these findings, the successful synthesis of useful elastic compounds has already been accomplished. Such results, however, are to be regarded merely as the beginning of an entirely new field of colloid research.

In NEW ENGLAND for
REPRODUCTION PROCESSES
Blueprints · Photostats
Ozalid Whiteprints
Photo-lithography
SPAULDING-MOSS CO
42 Franklin St. Boston 10, Mass

HAROLD J. RYAN, INC.

Air Conditioning

101 PARK AVENUE NEW YORK 17, N. Y.

McCREERY and THERIAULT

Building Construction

126 NEWBURY STREET BOSTON, MASS.

Lord Electric Company

INCORPORATED

ELECTRICAL CONSTRUCTION

131 Clarendon Street
Boston 16, Massachusetts
Telephone COM 0456

10 Rockefeller Plaza
New York 20, N. Y.
Telephone CI 6-8000

1201 Plaza Building
Pittsburgh 19, Pa.
Telephone COURT 1920

If It's Made — Ask ALBERT!

FOR IMMEDIATE DELIVERY
Odd and Large Sizes a Specialty
⅛" to 72"
LARGEST AND MOST COMPLETE STOCK on Atlantic Seaboard
Our Own Shop Facilities for Bending — Coiling — Welding — Threading and Testing —
Meeting All Standard Specifications
TUBE-TURNS, WELDING FITTINGS AND FLANGES

• PIPE	• VALVES	• FITTINGS	• PILING
Electric Weld	Iron Body	Welding	ARMCO
Seamless	Forged Steel	Tube Turns	Youngstown
Spiral Weld	Cast Steel	Fabricated	Pile Points
Lap Weld	and	Cast Iron	Cobi-Pile Tips
Butt Weld	Special	Forged Steel	Pile Sleeves
Steel—Wrought Iron	Alloys	Dresser	Cobi-Timber Tips
Corrugated Culvert		Victaulic	

STAINLESS STEEL PIPE, FITTINGS AND VALVES

S. G. ALBERT '29, *Treasurer*

ALBERT PIPE SUPPLY CO., Inc.

No. 13th & Berry Streets, Brooklyn, N. Y. EVergreen 7-8100

LEONARD CONSTRUCTION COMPANY

Engineers and Contractors

SINCE 1905

IN ALL THE AMERICAS AND FAR EAST

37 South Wabash Ave. Chicago

420 Lexington Ave. New York City

MONSANTO CHEMICAL COMPANY

Merrimac Division

EVERETT MASSACHUSETTS

The largest and oldest chemical manufacturer in New England

SYSKA & HENNESSY

Engineers

Consultation Plans Reports
Power Plant Disposal Plants
Water Systems

NEW YORK, N. Y.

J. F. HENNESSY '24

— STEEL —

HOT AND COLD ROLLED

Stahleker Steel Corp.

Second and Binney Sts., Kendall Sq., Cambridge 42, Mass.

Telephone Trowbridge 1440

WALLACE BLANCHARD, '16, *Treasurer*

SAFELY THROUGH ROUGH WATERS

(*Concluded from page 38*)

with a tremendous problem of navigating safely through the rough waters that have followed the storm. What we must all hope and pray and strive for is that we may navigate safely until, with time, the sailing has again become smooth, and we must all hope, pray and strive to prevent the outbreak of still another storm.

I think that the most important lesson which we can gain from this analogy is that the victory was not won with the advent of V-E Day and V-J Day, and that we cannot relax in our efforts, or relax our vigilance, or cease our sacrifices just because the wind has stopped blowing. We still have to navigate the waves, and to do so successfully will require the same patriotic zeal, sustained effort, and willingness to make personal sacrifices which enabled us successfully to ride through the storm of the war itself.

As you now go your various ways from the Institute and into the wide variety of careers before you, may you do so with faith and enthusiasm. There is no time like an emergency to create opportunities for a good man. You are actually and potentially good men, for you are a selected group who have had an unusual educational opportunity and have come through it successfully. If, added to your native ability and your educational training, you have faith and enthusiasm, and a sustained ambition to play a constructive role in these critical times, in whatever line of activity you may pursue, you will perform a much needed service in our postwar society and will win for yourselves success and satisfaction.

So, on behalf of the Faculty and the Corporation, I bid you Godspeed. If I may be permitted to speak on behalf of our Alumni Association, I welcome you to it. I assure you that the Institute and all connected with it will continue their desire to be helpful. Take advantage of this help by maintaining in various ways your contacts with M.I.T. and with your associates in class and Faculty. We shall follow your careers with interest and, I trust, with pride.

FAR EASTERN MANAGER

One year in India. One and one-half years in China. Presently on active duty (Lt. Col., U S. Army) in Tokyo. Excellent personal connections, official and private (American and Foreign) in Bombay, Calcutta, Hongkong, Shanghai, Tientsin, Tsingtao, Kunming, and Pekin. Well acquainted with official procedures. Broad administrative experience initiating new organizations, personnel, operations, supply, etc. Available to represent important interests. M.I.T. graduate, 1928, single, age 40.

Write Box D, The Technology Review

M.I.T., Cambridge 39, Mass.

PREPARATORY SCHOOLS FOR BOYS

CHAUNCY HALL SCHOOL

Founded 1828. The School that confines itself exclusively to the preparation of students for the Massachusetts Institute of Technology.

FRANKLIN T. KURT, *Principal* 553 Boylston Street, *Boston, Mass.*

HUNTINGTON SCHOOL FOR BOYS

Grades Nine to Twelve.
Thorough preparation for entrance to M.I.T. and other technical schools.
Regular and summer courses.

320 Huntington Ave., Boston Tel. Kenmore 1800

PROFESSIONAL CARDS

JACKSON & MORELAND
Engineers and Consultants

Design and Supervision of Construction
Reports — Examinations — Appraisals
Machine Design — Technical Publications

BOSTON NEW YORK

H. K. BARROWS, '95
M. Am. Soc. C. E.

CONSULTING HYDRAULIC ENGINEER

Hydro-electric Developments — Water Supplies. Reports, Plans, Supervision. Advice, Appraisals

6 BEACON STREET BOSTON, MASS.

EADIE, FREUND AND CAMPBELL
CONSULTING ENGINEERS

500 FIFTH AVENUE NEW YORK 18, N. Y.

Plans and Specifications — Examinations and Reports

Power, Heating, Ventilating, Electric, Plumbing, Sprinkler, Refrigerating, Elevator Installations, etc., in Buildings and Industrial Plants

J. K. CAMPBELL, M. I. T. '11

STARKWEATHER ENGINEERING CO.
INCORPORATED

Engineers and Contractors for Pumping Plants Boiler and Power Plants, Cooling Water and Heat Recovery Systems

246 Walnut Street, Newtonville BIGelow 8042

Wm. G. Starkweather, M.E. Cornell '92 — J. B. Starkweather, B.S. M.I.T. '21

H. A. KULJIAN & CO.
CONSULTANTS • ENGINEERS • CONSTRUCTORS

Specialists in
UTILITY, INDUSTRIAL and CHEMICAL FIELDS

1518 WALNUT STREET PHILADELPHIA, PA.

H. A. KULJIAN '19

FABRIC RESEARCH LABORATORIES
INCORPORATED

Research, Development and Consultation for Textile and Allied Industries

665 Boylston Street Boston, Mass.

W. J. HAMBURGER, '21 K. R. FOX, '40 E. R. KASWELL, '39

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

Malcolm G. Davis '25, *Vice President* Allen W. Reid '12 E. C. Edgar '35

Steam, Hydro, Diesel Power Plants; Industrial Structures; Plant Safety, Labor Relations, Utility Rates, Valuations, Reports; Large Scale Purchasing; Industrial Laboratory

New York, N. Y. Reading, Pa. — Washington, D. C. Philadelphia, Pa.

FAY, SPOFFORD & THORNDIKE
Engineers

Airports — Bridges — Water Supply and Sewerage
Port and Terminal Works — Fire Prevention

INVESTIGATIONS DESIGNS
SUPERVISION OF CONSTRUCTION

BOSTON NEW YORK

WALLACE CLARK & COMPANY
CONSULTING MANAGEMENT ENGINEERS
Since 1920

Planning for Research and Development, Engineering, Production, Quality Control, Maintenance, Surveys, Industrial Relations, Sales, Management Audits.

521 FIFTH AVENUE NEW YORK 17, N. Y.

MAURICE A. REIDY
Consulting Engineer

BRIDGES BUILDINGS
STRUCTURAL DESIGNS FOUNDATIONS
CONSTRUCTION CONSULTANT AND ARCHITECTURAL ENGINEER

Estimates and Appraisals

101 TREMONT STREET BOSTON, MASS.

THE COSMA LABORATORIES CO.
1545 East 18th Street Cleveland 14, Ohio

Chemical Analysis — Testing — Consulting Engineering
Testimony and Research

H. SEYMOUR COLTON, M.I.T. '21, *Director* — R. W. FRISCHMUTH, Case '38, *Assistant Director*

MORAN, PROCTOR, FREEMAN & MUESER
CONSULTING ENGINEERS

420 LEXINGTON AVENUE NEW YORK 17, N. Y.

Foundations for Buildings, Bridges and Dams; Tunnels, Bulkheads, Marine Structures, Soil Studies and Tests; Reports, Design and Supervision

Pardo, Proctor, Freeman & Mueser
Ingenieros Consultores
Ap. Correos 614, Caracas, Venezuela

WILLIAM H. MUSSER, '22
GEORGE T. GILMAN, '23

PALMER RUSSELL CO.
Realtors

Real Estate Brokers *Property Management*
Appraisals and Mortgages

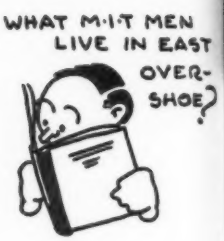
1320 BEACON STREET BROOKLINE, MASS.

Edgar P. Palmer '25 William W. Russell '22

FAirmount 5105 EXpress 7766

FRANK MASSA
Electro-Acoustic Consultant

3393 Dellwood Road 3868 Carnegie Avenue
CLEVELAND, OHIO



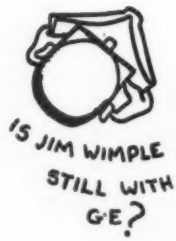
1948

ALUMNI REGISTER

Massachusetts Institute of Technology

TABLE OF CONTENTS

	Page
ALPHABETICAL LIVING SECTION — Name — Class Affiliation — Course — Degrees — Position — Firm — Address	1
ALPHABETICAL DECEASED SECTION — Name — Class Affiliation	277
WAR RECORD SECTION — Rank — Branch of Service — Period of Service — Decorations	301
CLASS LISTS — Living Alumni, Arranged by Classes — Deceased Alumni, Arranged by Classes	351
GEOGRAPHICAL SECTION — Location — Name — Class	453
MEMBERS OF CORPORATION SINCE 1865 — Name — Date of Membership	549
MEMBERS OF STAFF SINCE 1865 — Name — Department — Dates of Service	552



PUBLISHED AT THE INSTITUTE

Cambridge, Massachusetts

Ch
C.
M.O.

Application for New
ALUMNI REGISTER
Including M.I.T. War Record

THREE DOLLARS A COPY IN ADVANCE
(three dollars and fifty cents after Feb. 1, 1948)

Enclosed is $..... for.....copies of the 1948 Alumni Register to be delivered to me at the address below about April, 1948.

PLEASE PRINT

(First Name) (Middle Initial) (Last Name)

(Number) (Street)

(City) (Zone No.) (State)

Make check payable to the Mass. Inst. of Tech.

Return Application to

ALUMNI REGISTER

Massachusetts Institute of Technology

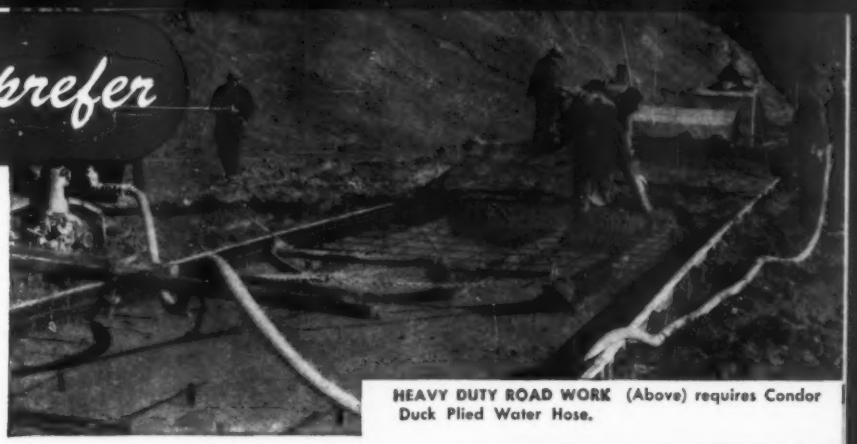
Room 7-104, Cambridge, Massachusetts

Mail Coupon Today
for a copy of the
1948 ALUMNI REGISTER

Valuable Information about 40,000 Technology Alumni.

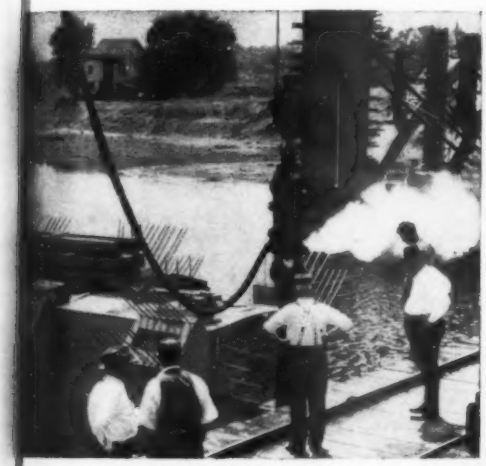
The War Record Section will be the only compilation to be published of M.I.T. Alumni who served in the Armed Forces during World War II.

Contractors prefer *Manhattan* HOSE



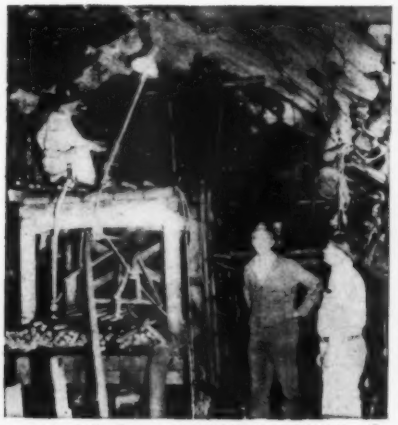
HEAVY DUTY ROAD WORK (Above) requires Condor Duck Plied Water Hose.

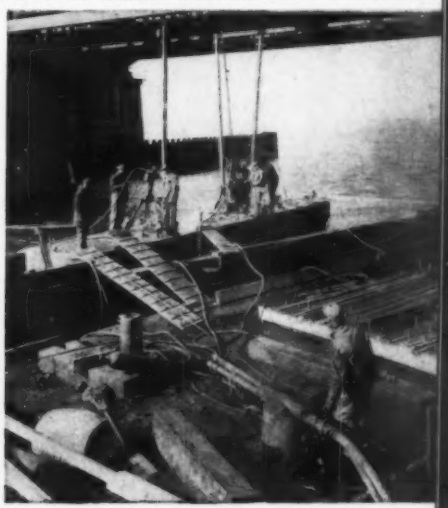
PILE DRIVING (Below) with Condor Pile Driver Hose on a bridge project.

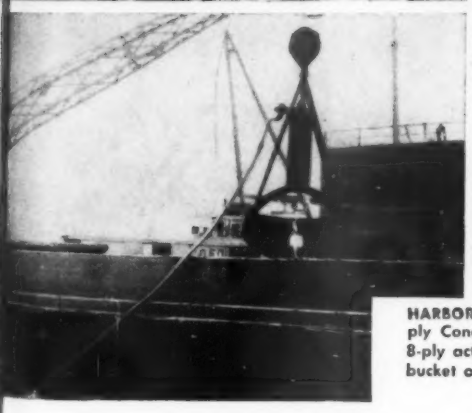


JACKHAMMERS—Right: Condor Homo-Flex Air Hose, lighter, easier to handle on Jackhammers. Exceptionally resistant to ragged rock punishment.

DAM EXCAVATION—Above: Draining low portion of a dam excavation, 300 G.P.M. against 90' head. Manhattan Suction Hose stands up on big jobs.







HARBOR WORK—Left: 2" 6-ply Condor Hydraulic Hose, 8-ply activating a clam shell bucket on a dredge.

NANTAHALA TUNNEL—Condor 2" Tunnel Air Hose and Homo-Flex Air Drill and Water Hose used in driving a 5-mile river-diversion tunnel in Nantahala, N.C.

RAILROAD BRIDGE — Above: Drilling 30' holes in concrete piers of old railroad bridge, job that calls for Condor heavy duck ply air hose on manifold feeds, and lighter, highly flexible Homo-Flex Hose on drills.

On jobs like those pictured here, profit depends on pushing up the schedules. You can't afford hose failures when men and machinery must wait for replacements. Condor hose constructions are engineered for the heavy demands of big projects. Each hose is built for a specific service . . . You can rely on Manhattan's 54 years of engineering experience for hose that keeps you ahead of schedule.

Bulletin 8688 shows many other case history photos of Manhattan hose, conveyor belts, transmission belts and V-belts in action on history-making construction jobs. Your copy will be sent with no obligation.

RAYBESTOS R M MANHATTAN

RAYBESTOS-MANHATTAN INC.

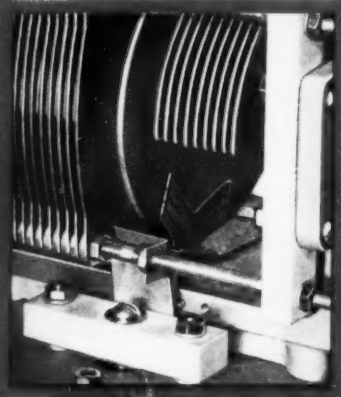
Keep Ahead with Manhattan

MANHATTAN RUBBER DIVISION **PASSAIC, NEW JERSEY**

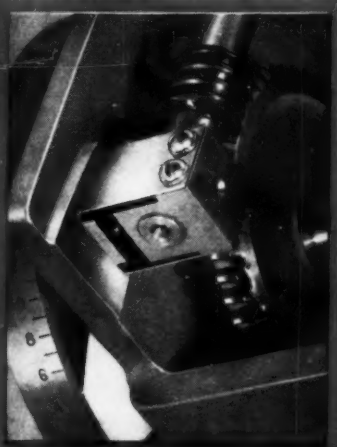
Thomas H. Boyd '23 Wilder E. Perkins '25 Charles P. McHugh '26 Daniel J. Hanlon '27 Albert W. Bowker '40

Even GREATER Accuracy

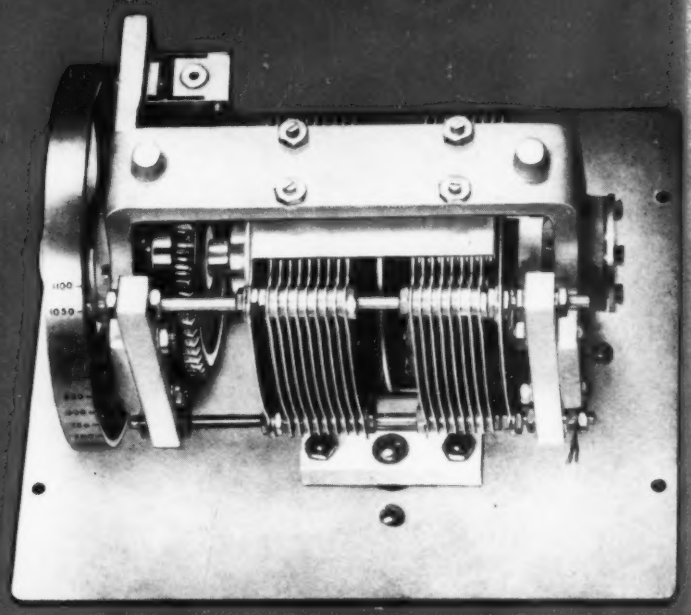
This 50-to-1 worm drive, equipped with a 3½ inch dial, is used for the fine setting adjustment. Backlash in the drive is kept very low by cutting the worm and its shaft from an integral steel shafting, eliminating eccentricity due to setscrews and misfit.



Two small, waxed steatite bars insulate the stator plates. A Figure of Merit ($R_\omega C^2$) of 0.05 x 10^{-12} is secured. Connection to the rotor is made by spring-tempered silver alloy brushes bearing on a silver-overlay brass disc.



The worm shaft is held to a tolerance of 0.0004 inch; radial eccentricity of the worm gear is less than 0.002 inch. The main rotor shaft is held to a tolerance of 0.0005 inch and its bearing surfaces to 0.0002 inch. Ball bearings are used on worm and main rotor shafts.



from this PRECISION CONDENSER

Long used as *the* standard of variable capacitance thoughout the measurements industry, the G-R Type 722 Precision Condenser has recently had its guaranteed accuracy increased.

All models of the Type 722 condenser are now supplied with a correction chart on the front panel. The Type 722-N Precision Condenser (illustrated) is direct-reading to ±1 $\mu\mu$f. When the charted corrections are applied to the direct-reading settings the accuracy is increased to ±0.1% or ±0.4 $\mu\mu$f, whichever is greater, and correspondingly the accuracy for capacitance differences is ±0.1% or ±0.5 $\mu\mu$f.

SPECIFICATIONS

- **CAPACITANCE RANGE:** 100 to 1100 $\mu\mu$f, direct reading
- **STANDARD CALIBRATION:** Direct reading in $\mu\mu$f at 1 kc to ±1 $\mu\mu$f. Mounted correction chart gives corrections to 0.1 $\mu\mu$f at multiples of 100 $\mu\mu$f
- **WORM CORRECTION CALIBRATION:** For very precise measurements a worm correction can be supplied. When worm corrections are applied capacitance can be determined within ±1 $\mu\mu$f or ±0.1%, whichever is greater, and capacitance differences to ±0.2 $\mu\mu$f or ±0.1%
- **METALLIC RESISTANCE:** Series resistance about 0.008 ohm at 1 Mc
- **SERIES INDUCTANCE:** Approximately 0.024 μh
- **TEMPERATURE COEFFICIENT:** Approximately ±0.002% per deg. C. for small changes

TYPE 722-N PRECISION CONDENSER . . $160.00
Worm Correction Calibration **50.00**

ORDER NOW — A few in stock.

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

New York Chicago Los Angeles